

CHANGES IN INFANT SLEEP QUALITY AND NEGATIVE EMOTIONALITY

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by

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Abstract

Forming healthy sleep-wake patterns in infancy can be beneficial not only for the infant themselves but parents as well. The development of sleep can be seen through both sleep-state organisation and sleep consolidation. This is vitally important as sleep plays an important role in brain development, as well as promoting health. Furthermore, when healthy sleep-wake patterns are not established in early infancy, the development of infant sleep problems may arise. Gradual behavioural interventions for infant sleep such as extinction with minimal check and extinction with parental presence, have shown to improve sleep behaviours through parental report. However, the nature of change is unknown, specifically do interventions change infant sleep behaviour or sleep-state architecture? Infants who do continue to require parental intervention and attention for sleep could in part be due to their temperament. Nine participants aged 12-18 months were recruited for this study, six of which had received a behavioural intervention for ISD and three which had not. VSG data was recorded during four phases, namely, baseline, intervention, post-intervention and follow-up. This data along with sleep diary data was analysed to answer the following questions; Firstly, was the gradual intervention effective in reducing ISD? Secondly, were changes shown in infant sleep behaviour or infant sleep architecture? And thirdly, was there any change in infant negative emotionality in relation to sleep changes? Results showed that a gradual behavioural intervention was effective in reducing infant ISD behaviours. Changes in sleep state architecture and sleep behaviours of infants were observed, as well as a change in negative emotionality of intervention infants. Therefore, this research provides some insight on how interventions effect the sleep of infants and how temperament may play a crucial role in ISD.

Within the first year of life, growth and changes occur rapidly in all aspects of infant development (Eugene & Masiak, 2015), including the development of healthy sleep-wake cycles. The development of healthy sleep-wake cycles may be more difficult for some infants than others, however literature suggests that developing healthy sleep-wake cycles also has beneficial outcomes in other areas (Sadeh, 2005). One major aspect that is of concern to professionals is sleep problems in infants over 6 months of age, such as bed-time resistance, sleep onset delays and night wakings. Due to the nature of sleep problems and their potential to carry on into adolescence and even adulthood (Dahl, 1996; Sadeh, 2005), professionals may take a certain interest into finding ways to minimise and eliminate such problems. Another difficulty of sleep problems is that they may act as a foundation for other complications to arise, previous research has found correlations with, family stress (Sadeh, Raviv & Gruber, 2000), parental psychopathology (Dahl 1996; Lam, Hiscock & Wake, 2003; Morrison, McGee & Stanton, 1992; Sadeh, Gruber & Raviv 2002), compromised neurobehavioral functioning (Gozal, 1998; O'Brien, Holbrook, Mervis, Klaus, Bruner & Raffield, 2003), difficult temperament (Carey 1974; Sadeh, Lavie & Scher, 1994) as well as behavioural problems (Dahl, 1996).

For younger infants, (below four months) nocturnal parental intervention and non-consolidated sleep patterns are typical of a developing sleep pattern (Henderson, France, Owens & Blampied, 2010) and not considered problematic among both professionals and parents. The majority of infants tend to follow a typical development of sleep patterns, where from four months of age and above, they can sleep throughout the night, without the need for constant parental intervention and soothing techniques (Henderson, et al., 2010). When infants reach six months of age and are still exhibiting sleep behaviours such as, sleep onset delay (SOD) and recurrent night wakings and are needing constant nocturnal parental

intervention then this may be considered problematic and described as Infant Sleep Disturbance (ISD). ISD is very common in infancy (Sadeh, 2005) with around 15-35% of infants presenting in this way (France, Blampied & Henderson, 2003).

Infant sleep problems need to be considered in the wider context of the family as well as the infant themselves. Expanding on this, infant sleep problems are related to parental behaviours (Sadeh et al., 2000), and to infant temperament (Carey 1974; Sadeh et al., 1994). Therefore, to provide insight into the underlying components of sleep problems, it is important to objectively measure these variables, for example measuring difficult temperament by using a measure of negative emotionality.

Some parents accept and cope with such sleep problems, seeing them as a typical part of development, others may need interventions to decrease family stress and parental distress, (Sadeh, 2005) that may develop as a result of infant ISD. If this is the case, then behavioural interventions need to be tailored for each infant. The manner in which they are tailored depends on age.

At 24 months of age, infants have typically developed communication skills, (Sadeh, 2005) providing the opportunity for interventions to be language based and different from those that are used with younger infants who have not developed language. Previous research into behavioural interventions for infants has shown that they are beneficial and can help increase infant sleep consolidation (Wilson, 2013). They also show that behavioural interventions can decrease family stress, and parental psychopathology (Sadeh, 2005), which may be beneficial for the parent-child relations.

However, the nature of this sleep improvement is still unknown. Specifically, how does sleep change and what is considered to be an improvement? It is unclear if behavioural interventions (which change parental responding), are resulting in changes in self soothing

behaviours of infants, in underlying sleep architecture and in other assumedly biological correlates of sleep problems such as negative emotionality. More specifically, do infants simply increase their self-initiated settling behaviours by increasing their self-soothing capability and reinitiating sleep on their own accord without signalling to parents, or is the quality of their sleep actually changing? Does the sleep architecture change, in that sleep is consolidated, there is a decrease in sleep-wake transitions and a change in proportion of sleep states? Or do both outcomes occur? Finally, does any change in self-soothing reflect a change in assumedly stable temperamental characteristics such as negative emotionality?

To understand these questions, this literature review will look at the development of sleep and how sleep state organisation and sleep consolidation occur. Secondly it will look at why the development of sleep is important, in relation to cognitive development, brain development and the promotion of healthy psychological outcomes in infants and parents. Thirdly, how sleep problems, namely Infant sleep disturbance (ISD) may develop will be considered in the light of two models including how both individual and parental characteristics may contribute to ISD. Next, the literature review will focus on temperament and its interaction with ISD. The literature review concludes with a consideration of behavioural interventions, and how help can be offered to those parents who may decide ISD is a concern and require additional resources to cope.

The Development of Sleep

The development of sleep is important and a concern to professionals as evidence suggests sleep problems can continue on into adolescence and adulthood (Dahl, 1996; Sadeh, 2005). An early marker of biobehavioural organisation and adaptation in infants is that of sleep-wake patterns. The developmental process is complex and involves biological,

physiological and psychological progression that ideally leads to consolidated sleep patterns (Sadeh et al., 2000). The development of a consolidated sleep-wake cycle typically involves two processes; a shift from fragmented sleep patterns to longer sleep-wake cycles, (where sleep ideally occurs at night and awake periods at day) and a slow reduction of overall sleep, with increased awake times (i.e. later bedtimes). Newborn infants appear to sleep around 16 out of 24 hours a day, cycling through different episodes of sleep and brief awakenings in both night and day sleep. As infants age and develop, this consolidates and the duration of both extended sleep and awake periods increase (France & Blampied, 1993). The development of sleep can be shown through sleep state organisation, sleep durations and night wakings.

Sleep state organisation

Infant sleep is generally categorised into two states, Active (REM) and Quiet sleep (NREM). Active sleep is comprised of rapid eye movement, sporadic actions and uneven breathing patterns (Anders & Keener, 1985). In active sleep an infant commonly experiences twitching movements of hands and face and also a suckling movement of the mouth (Dittrichova, 1966). Quiet sleep is comprised of regular breathing, closed eyes without movement, reduction of body movements, and spindles/slow waves in an EEG recording (Dittrichova, 1966).

Active and quiet sleep cycles throughout the night, with quiet sleep clustering earlier on in the night and active sleep becoming more prevalent towards the end of the night and closer to awake times (Anders & Keener, 1985). They are also related to the age and development of infants. The durations of these cycles and the temporal distributions are different from neonate to childhood and adulthood (Ellingson 1985, as cited in Blampied &

France, 1993). Meaning, as infants age and their sleep states develop, it is typical to see overall quiet sleep states increasing in durations and active sleep decreasing (Dittrichova, 1966). Before 6 months of age, infants active sleep consumes between 47-50% of total sleep time and this decreases to 29-49% after 6 months of age (Anders & Keener, 1985; Parmelee, Schulte, Akiyama, Weener, Schultz & Stern, 1968), while quiet sleep increases from around 19-26% at birth to 40-42% at six months (Anders & Keener, 1985; Parmelee et al., 1968). This change is significantly seen in the first year of life, with slower less dramatic changes occurring later on, such as later bedtimes, a disappearance of day naps and the reduction of overall sleep time (Sadeh et al, 2000).

The development of sleep consolidation

One of the most important early factors contributing to sleep duration is age. As infants age their sleep duration begins to typically increase. New-born infants tend to sleep around 16 hours in a 24-hour period, however this decreases as infants age and mature, with sleep duration being around 13 to 14 hours at 6 months (Sheldon, 2006). With this reduction of sleep comes less fragmentation, where early infancy sees awake and sleep periods distributed throughout the day and night however around 6 months of age, sleep occurs mostly at night with less fragmentation. This change in sleep is also due to infant sleep becoming entrained to a circadian rhythm (Salzarulo & Ficca, 2002).

The duration of sleep can be measured in different ways, through the longest sleep period (LSP) and the longest self-regulated sleep period (LSRSP). The longest sleep period is a measure used to approximate the maturation of sleep organisation by measuring the physiological capacity of infants to stay in a continuous sleep state (Anders, Keener, Bowe & Shoaff, 1983; Henderson et al., 2010). It refers to a state in which sleep occurs continuously

in the absence of an awake state. The LSP is typically expected to increase as the age of infants increases. At two weeks of age infants tend to typically have an LSP of around four hours, which increases to around seven hours by the age of five months (Anders & Keener, 1985). The longest self-regulated sleep period (LSRSP) refers to the longest period an infant is in a state of sleep, together with silent arousals which are followed by the re-establishment of self-initiated sleep through self-regulated self-soothing. This concept is relatively new in sleep research; however, it incorporates a fundamental aspect of infant sleep development; namely the ability of infants to re-initiate sleep on their own after an arousal (Henderson et al., 2010) in the absence of signalling. This is measured by taking the longest sleep period in combination with consecutive periods of silent arousals, followed by sleep. This is an important aspect to consider, as it shows the development and maturation of sleep-state organisation, showing the infant's ability to self-soothe and not need parental interventions.

Night wakings are related to the duration of sleep and occur when the infant awakes in the night. Night wakings can be either signalled or non-signalled. A signalled awakening is any awake period of the night where the infant indicates to the parent, they are awake. For example, crying, fussing, calling out, and/or including any other signalling behaviour that alerts the parents the infant is awake (France & Blampied, 1999). Non-signalled awakenings are where the infant self-soothes and initiates sleep on their own without external intervention. Night wakings are generally considered to decrease as an infant gets older, with the goal of sleeping throughout the night. However, as most research (Sadeh et al., 2000), done on this phenomenon is based on parental reports (i.e. sleep diaries) it is difficult to tell if infants do actually decrease the number and duration of night wakings or alternatively increase wakeful self-soothing behaviour (silent as opposed to signalled

awakenings). This means, instead of consolidating sleep by waking less, the infant may still awaken, however they no longer signal for parental intervention and therefore the parent is oblivious to the awakening. These silent awakenings can be detected using videosomnography (VSG), where the infant is recorded, and this recording is later coded to determine sleep states and phases of the infant's sleep pattern, also showing how the infant is behaving in any silent awakenings. The use of VSG and the nature of night wakings are immensely important in determining if sleep 'quality' is changing.

The development of sleep patterns is a complex task with many interconnecting pathways as well as beneficial outcomes in other developmental areas (i.e. cognitive). The major shifts occurring for healthy development are the increases in quiet sleep, the decreases in active sleep, the increase in the duration of sleep and less fragmentation of these sleep-wake cycles. However, if healthy sleep patterns do not develop there is the potential for challenging sleep behaviour to arise.

The Importance of Sleep

Sleep plays a critical role in promoting health and wellbeing in individuals (Sadeh, 2005). Sleep is important to development and we assume that increasing sleep or sleep consolidation will enhance development, however different aspects of sleep affect development differently. The following section will look at the role of sleep in brain development, namely how the different sleep states contribute to brain maturation, as well as the sleep architecture in relation to promoting health.

The role of sleep in brain development

Different sleep states, namely Active and Quiet sleep appear to contribute to brain development both individually and collectively (Dang-Vu, Desseilles, Peigneux & Maquet, 2006). A study done by Becker and Thoman (1981), looked at a phenomenon called REM bursts and their relationship with mental development six months later. REM bursts occur during active sleep and refer to a surge of rapid eye movement, which is sometimes accompanied by other facial movements such as eye opening and brow raising (Becker & Thoman 1981). The reduction of REM bursts throughout development in the first year of life is typically suggested to show maturation of sleep organisation and consolidation. Becker and Thoman (1981) used the Bayley Scales of Mental Development and correlated scores with the amount of REM bursts, for each infant. It was found that increased REM bursts at 6 months old had negative correlations with the MDI at 1 year. Therefore, suggesting that decreased REM bursts are beneficial for infants as they age, and conversely increased REM bursts at 6 months of age may suggest dysfunction or delay in sleep organisation.

However, on the other hand, in a very different group of infants, a study done by Arditi-Babchuk, Feldman and Eidelman (2009) looked at REM in premature neonates and their developmental outcome at 6 months. Sleep wake cycles and periods of REM were assessed over 4 evenings when infants were 32 to 36 weeks post menstrual age. This study found no associations between REM bursts and later development. However, a possible limitation of this study could be that new-borns were premature and for that reason this cannot be generalised to full term, older babies. As brain plasticity is highest in early infancy (Dang-Vu et al., 2006), this could be a potential influencer on why active sleep is also highest in early infancy. As infant's brains tend to change and develop more this means more sleep is required to consolidate this new information they are being presented with. Therefore, it

may be that sleep consolidation and maturation is important for cognitive development, however this may not always be the case as there is contradictory evidence.

Quiet sleep may also be an important factor in brain development. Crowell, Kapuniai, Boychuk, Light and Hodgman (1982), looked at daytime sleep state organisation in three-month-old infants. They found a significant relationship between sleep states at 3 months old and mental performance at 12 months, specifically finding that an increased level of quiet sleep and decreased periods of fragmentation are beneficial. This is further supported by a study, done by Beckwith and Parmelee (1986) who looked at EEG patterns of preterm infants, sleep state organisation and later IQ. They found that infants with higher levels of high voltage slow waves in quiet sleep, consistently scored higher on developmental tests from age 4 months till 8 years. High voltage, slow waves suggest a spasm-like movement in the infant and occur in quiet sleep as well as state transitions (Kobayashi, Oka, Inoue, Ogino, Yoshinaga, & Ohtsuka, 2005). This suggests that quiet sleep is also important for brain development in early infancy. However, this study is also limited by the fact it was done with preterm infants and also cannot necessarily be generalised to term or older infants. Nonetheless, literature suggest that both quiet and active sleep states are important for higher cognitive development and brain functioning.

Sleep Architecture and Promoting Health

Sleep architecture refers to the basic structural organisation of sleep, for example REM and NREM cycles, (Colten & Altevogt, 2006). When investigating sleep fragmentation and disturbances in terms of architecture we can refer to a study done by, Sadeh, Raviv and Gruber (2000). They looked at sleep patterns and sleep disruptions with the use of actigraphy, sleep questionnaires and daily reports. It was found that sleep fragmentation

and increased number of sleep wake cycles (evident in unconsolidated sleep patterns) were correlated with family stress. This shows that the sleep architecture of infants where there were fewer sleep-wake cycles was beneficial. This was further supported by Hiscock and Wake (2002) who looked at sleep problems in relation to parental psychological health and infant sleep patterns. They concluded that parents of infants with difficult sleep patterns appeared to have a lower mood and expressed depressive symptoms compared to parents of infants with healthy and consolidated sleep patterns. This was further supported by Lam, Hiscock and Wake (2003) who conducted a longitudinal study looking at infant sleep problems, behaviour and maternal well-being. In this study they concluded that maternal depression was also higher when infants presented with sleep problems.

Therefore, suggesting that not only is a consolidated pattern of sleep important for infant development it is also important and beneficial for infant-parent relationships and psychopathology in regard to family stress and depressive symptoms. In conclusion, from the studies mentioned above it is evident that sleep is correlated to psychological outcomes in the family system and has the potential to promote health in parents.

The Development of Sleep problems

Sleep problems are prevalent throughout life and may start as young as infancy (Dahl, 1996). Most infants can sleep throughout the night at four months old with no explicit intervention from parents (Henderson, France, Owens & Blampied, 2010). Approximately 15-35% of infants (Blampied & France, 1993) are affected by sleep problems in their early childhood and of these infants, some parents choose to intervene to help their infant develop certain behaviours to initiate and maintain sleep throughout the night (e.g. self-soothing). Sleep problems, sometimes called Infant Sleep Disturbance (ISD) are complex

and involve many different factors acting upon each other. ISD may also then act as a precursor to other difficulties such as family stress (Sadeh, 2005), parental psychopathology (Dahl, 1996), and behavioral/emotional regulation problems in infants (Sadeh, 2005), and low mood, depression and increased fatigue in parents (Matthey & Crnec, 2012). There are two models which explain ISD in different ways, a family systems model (Sadeh & Anders, 1993) and a bio-behavioural developmental model (Blampied & France, 1993; France & Blampied, 1999) which are explained below.

Infant Sleep Disturbance

Infant Sleep Disturbance (ISD) includes difficulties settling to sleep (i.e. sleep onset delay), and recurrent night wakings, which are frequently accompanied by co sleeping and crying, (France & Blampied, 1993). Some parents may consider this to be challenging and problematic. It is also shown that sleep problems don't just present in infancy but may also carry on into later childhood, adolescence and even adulthood (Field, 2017). A sleep disturbed infant may be unable to settle back to sleep on their own accord, without the parents being alerted to the awakening (France & Blampied, 1999) and having to intervene. Active (REM) sleep is associated with complete arousals (France & Blampied, 1999), and in infant sleep there is a larger proportion of active sleep than in adult sleep, meaning more potential possibilities for arousals. During these arousals, infants presented with ISD signal to parents and need aid to resume sleep, rather than self-initiation and self-soothing behaviour (France & Blampied, 1999).

Sadeh and Anders (1993)

ISD can be explained by Sadeh and Anders's (1993) systems model. They define two

core features; components and outcomes. These features are related bidirectionally, meaning they can both influence one another. For example, components can influence sleep of an infant, and define the outcomes and on the other hand the outcomes can influence the components of an infant's sleep. Sadeh and Anders (1993) further categorise components into proximal or distal and extrinsic (factors outside the infant) or intrinsic (factors within the infant). Proximal components include those closest to the infant, such as parents, and distal components are influencers such as culture. Distal factors can therefore be influenced or influence intrinsic or extrinsic factors, where distal extrinsic components refer to parental psychopathology, parental personality or parental representations and distal intrinsic refers to infant development or infant temperament. All these components act as combining forces that influence an infant's sleep. For example, family dynamics can influence the sleep patterns of an infant, and infant sleep patterns can influence the family dynamics. This is important to note as they highlight that changes in one aspect of an infant's life can have cascading effects and also influence other aspects.

When taking all these factors into consideration, Sadeh and Anders (1993) propose interventions efforts and ISD diagnoses to consider the family system as a whole, and how the different factors interact with one another, rather than attempting to decrease ISD with efforts solely focused on the infant.

Blampied and France (1993); and France and Blampied (1999)

In these models, Blampied and France, (1993) and France and Blampied (1999) propose, that infant and parent interactions in the first 6 months, may define the sleep patterns and behaviours infants go on to develop. They further categorise infant sleep disturbance into primary ISD and secondary ISD.

The challenges and demands that the parents face in those first six months, allow the infant to develop or fail to develop certain techniques such as self-soothing behaviour. As an infant gets older, their need for regular feeding throughout the night decreases and their sleep organisation becomes more consolidated (France & Blampied, 1999). These cycles of sleep can include partial arousals, where the infant awakens but is able to self-initiate sleep, or complete arousals where there is increased wakings and crying and the need for parental intervention (France & Blampied, 1999). The nature of these arousals is also influenced by other factors such as the maturity of sleep state organisation, meaning the sleep states (Active and Quiet sleep) are clearly distinguished which is further influenced by individual and parental factors (discussed later on). At this stage if infants can initiate self-soothing when awakenings occur then ISD will not develop, however if awakenings cue for parent intervention then primary ISD may develop depending on the parent's reaction (France & Blampied, 1999). If parental attention is reinforcing then crying may continue, if not then crying frequency should ideally decline (France & Blampied, 1999). This model assumes that the way in which parents put their infant to sleep at the beginning of the night, will mimic what the infant requires when they awake during the night. For instance, in the case of a sleep disturbed infant, the infant's behaviour of calling out and signalling will be reinforced by inappropriate stimuli when the parents adhere and provide parental intervention to help with the re-initiation of infant sleep. These behaviours become more and more intense; as an infant increases their signalling behaviours, parents increase their intensive stimulation (i.e. rocking and feeding behaviours). This model goes on to explain that a coercive behaviour trap occurs when both the infant and their parents attempt to avoid aversive behaviours. In case of the parents, aversive behaviour they avoid would be infant distress, and in case of the infants it would be falling asleep in unfamiliar

circumstances (France & Blampied, 1999). As parents attempt to avoid aversive behaviours, the infant responds by increasing their signalling and crying out, this then in turn sees parents intermittently reinforcing the infant's behaviours by occasionally providing intervention. Consequently, as a result of parents responding to infants intermittently, the coercion trap is strengthened as these behaviours reinforce the infants crying to a more intensive level. On the other hand, if interaction from parents is low stimulating and reduced or withdrawn at bedtime (also known as extinction) then infants may learn to self sooth and reinitiate sleep on their own.

Secondary ISD occurs when infants have settled to regular, continuous sleep around 6 months age, but revert to waking and crying (France & Blampied, 1999). Secondary ISD, can be initiated after an event occurs, which disrupts the infant's previous sleep patterns, such as sickness, birth of a sibling, and or a change in family circumstances (France & Blampied, 1999).

Individual and Parental Characteristics

Individual and parental characteristics of infants and parents, whose infants present with ISD, may differ from those infants and parents whose infants do not have ISD. When looking at these differences it can be noted that infants with ISD appear to sleep less and cry more, have a more difficult temperament, difficulty self-soothing and have consistent sleep disturbance (France & Blampied, 1999). These infants also have increased chances of having earlier colic (excessive fussiness) and showing certain behavioural and temperamental qualities associated with increased levels of crying, high irritability scores and low scores for adaptability and mood (France & Blampied, 1999). Research has also shown that these infants with ISD differ from those whose sleep is consolidated as they use less self-soothing

behaviour, less self-comforting and rely on parents to intervene (France & Blampied, 1993).

Parental characteristics also differ among the two groups (parents whose infants have ISD and parents whose infants do not). Parents of infants exhibiting ISD also use strategies such as staying with their infants till they fall asleep, co sleeping, putting infants to bed asleep and feeding their infant during the night (Anders, Halpern & Hua, 1992; Sadeh, Tikotzky, & Scher, 2010; Tikotzky, 2017; Zeifman & James-Roberts, 2017). These parents are also more likely to use a large variety of management techniques, but more importantly they tend to use different techniques from the parents of non-sleep disturbed infants. Therefore, it is shown that both infants with ISD and parents whose infants have ISD show different characteristics to parent and infants with no ISD. The direction and complexity of this relationship however needs to be considered. Infant sleep patterns may result from the infant responding to the environment, but the environment can also influence the infant (France & Blampied, 1999). For example, parents using different techniques could be more likely to have infants with ISD, but on the other hand infants with ISD may be requiring different techniques resulting in increased stress in parents. Conversely, infants with sleep problems may have different 'natures' (i.e. temperament) from those who do not present with sleep problems and can be a potential influencer on why ISD occurs in this certain group.

Temperament

The following section will look at temperament in regard to its relationship with sleep. There are different models and evaluations of temperament, used throughout the literature. Two leading theories are that by Chess and Thomas (1966) and the other by Kagan (1984). This section will go on to describe both theories however, the focus will be on

Chess and Thomas and their theory of difficult temperament as this approach to temperament is more prominent in the infant sleep literature than that of Kagan (1984).

Previous research has shown that infant sleep problems may be related to temperament (Carey 1974; Sadeh et al., 1994). The underlying concept of temperament is that it is assumed to be inbuilt, even though its expression may be modified by experiences, the core of temperament is inbuilt. There are a number of ways to conceptualise temperament, firstly Kagan takes a biotypological approach. Centre stage to Kagan's theory is this idea of behavioural inhibition and how specific areas of the brain are involved in the inhibition of certain behaviours in infants. Kagan theorizes that children belong to certain categories of temperament and these discrete categories are produced as a result of different biological factors. According to Kagan, these categories are comprised of high versus low reactive and uninhibited versus inhibited children. Kagan, (2003), looks at four-month-old infants and categorises high reactive infants as showing vigorous motor activity, and distress to unfamiliar stimuli (visual, auditory and/or olfactory). Of this high reactive group, in their second year of age when proposed with unfamiliar events they become shy and timid, however one third of this group shows extreme signs of fearfulness and this group is subsequently termed inhibited. On the other hand, four-month-old infants that show low levels of activity and very little irritability, to the same stimuli are termed low reactive. These infants at two years of age are more likely to be sociable and fearless, however one third show minimal signs of fearful behaviour and these infants are grouped as the uninhibited children (Zentner & Shiner, 2012). Although Kagan looks at temperament in regard to infant behaviours, his research does not appear to relate specifically to infant sleep behaviours. Therefore, the focus will now be on Chess and Thomas and their conceptualisation of temperament.

Temperament as defined by Chess and Thomas is the way in which some individuals respond to novel stimuli. They define temperament according to the 'how of behaviour'. For example, they define according to the intensity of a child's cry, rather than what a child does when they cry or why the child is crying (Zentner & Shiner, 2012). At the centre of their theory they describe the concept 'goodness of fit', as the environment affects the child and the child affects the environment, they explain how parental behaviour and upbringing should be individualised to each child's temperament, instead of an overall 'parenting technique', to ensure healthy psychological development. According to Chess, Thomas and Birch there are nine different categories of temperament, which are activity level, rhythmicity, approach or withdrawal, adaptability, threshold of responsiveness, intensity of reaction, quality of mood, distractibility, attention span and persistence (Zentner & Shiner, 2012). These nine categories are further grouped, into three classifications, namely easy temperament, difficult temperament and the slow to warm up temperament. This proposed terminology that Chess and Thomas use has also been used further in the development and implementation of several questionnaires and forms for parents, caregivers and teachers.

Chess and Thomas conducted a study which is widely known and a core concept for the temperament research as a whole, called the New York Longitudinal study. From this sample, they proposed classifications of the above three categories. Children with an easy temperament were shown to develop regular sleep and feeding schedules, adapt to new food and smile at strangers, these children made up 40% of the studies sample. The next category was difficult temperament, these children showed negative withdrawal responses to new stimuli, no adaptability to change and intense negative mood expressions, as well as irregular feeding and sleep patterns, this group of children made up 10% of the sample. However, it was also found that not all children fit into one of the three categories, some

overlapped and belonged to more than one. At this point, it is important to note that although each of the above categories implies different attributes, (for example a difficult temperament implies negative characteristics) one temperament category is not considered more “normal” (or abnormal) than any other. Another important note is that even though temperament is an underlying concept and cannot be changed, individuals can learn to control and adjust to certain difficulties (Zentner & Shiner, 2012) and manage their different temperamental tendencies.

Previous research has shown that infant sleep problems may be related to temperament (Carey 1974; Sadeh et al., 1994). For example, a study done by Kelmanson (2004) looked at temperament and sleep characteristics in two-month old infants. Temperament and sleep behaviour information was gathered through questionnaires and analysed to show that infants with increased negative mood and distractibility (difficult temperament) had decreased sleep duration, required more attention from parents in initiating sleep and had increased night waking frequency. This was further supported by a study done by Sorondo and Reeb-Sutherland (2015) who looked at the associations between infant temperament, maternal stress and infant sleep across the first year of their life. In this study they also used maternal reports to assess infant temperament and sleep behaviours. It was concluded that difficult temperament was associated with sleep problems in infants.

It is important to note from the literature mentioned above, that although associations are found with difficult temperament and infant sleep problems, it is evident that most temperament measures are measures of perceived temperament, namely they are based on parental reports. Although these are effective due to the simple questionnaire form and is overwhelmingly the most common measure of temperament used, the

behaviours parents report, may be largely based on parent cognitions and cultural views.

Perceived temperament may therefore become biased and unreliable due to parent influences and personal emotions.

In this instance, it may seem that objective measures of this component of temperament are needed as they as they do not rely on parental reports. One objective measure of difficult temperament can be taken through measuring negative emotionality which refers to irritability, negative mood, (un)soothability, and high intensity of negative reactions to stressful situations (Paulussen-Hoogeboom, Stams, Hermanns, & Peetsma, 2007). Objective measures of temperament eliminate parent cognitions and influence from the data and focus on infant behaviours. Although perceived temperament appears to be associated with sleep problems it is important to ask the questions; are the objective aspects of negative emotionality also associated with sleep, as the perceived measures are? If so, is this an unchangeable determinant of infant sleep or does temperament itself change along with sleep and self-soothing behaviours?

Behavioural Interventions

Infants' sleep patterns may be improved and changed to become more manageable, for both parents and infants themselves, however the age of the child does provide certain limitations to this. Once children have reached the age of two, sleep disruptions can be improved through implementing verbally mediated reward programs in addition to certain extinction techniques, (France, Blampied & Henderson, 2003). For children under the age of two, limitations such as language and cognitive barriers make verbally-mediated interventions harder, if not impossible, to implement. For infants under 24 months old, behavioral interventions which focus on infant sleep, modifications of systematic ignoring

such as minimal check and parental presence procedures are commonly taught to parents wanting to intervene to improve their children's sleep. Children under the age of 6 months may be the focus of prevention programmes but it is not recommended that they receive sleep intervention programmes (France, Henderson & Hudson, 1996).

A behavioural intervention is where the principles of applied behaviour analysis and social learning theory are implemented in the effort to change how an individual respond to a particular object or event (Owens, France & Wiggs, 1999). As infants pose a language barrier, most interventions used are behavioural rather than cognitive-behavioural. A cognitive aspect is still included for the parents, as most parents need to alter their beliefs and thoughts (Owens, France & Wiggs, 1999) about their infants' sleep in order to achieve a successful outcome.

Systematic Ignoring is based on the behavioural principle of extinction. Extinction is centred around the concept that the behavioural sleep problems of infants are being maintained by excessive parental attention and intervention (Owens, France & Wiggs, 1999). Extinction is where reinforcers such as attending to the child on signalling are eliminated or reduced, unless the parents judge the infant's signalling as necessary for health or safety. This method results in a rapid decrease in the problematic behaviours of infants (Owens, France & Wiggs, 1999). A study done by Gradisar, et al. (2016) looked at behavioural interventions and their impact on infant sleep problems through a randomized control trial. They used a gradual systematic ignoring intervention and found that infants cried less as well as decreasing awakenings throughout the night.

Minimal Check and Parental Presence procedures are both modifications of the extinction intervention. Minimal Check is where the parents check on the crying infant at predetermined brief intervals, where intervals have ranged from five to 20 minutes (Owens,

France & Wiggs, 1999). Parental Presence programs are based on the concept of unmodified extinction and the attempt to relieve separation anxiety by avoiding the separation component during extinction (as the parent is still present). In more detail, its assumed infants exhibit behaviours such as crying due to their separation from parents when they are put to bed. In this program, the parents sleep in the same room as the infant in a separate bed for about a week. However, throughout the night the parent is to have no interaction with the infant, even if the infant awakens. A study by France and Blampied (2005), looked at modifications of systematic ignoring in the management of infant sleep disturbance. Systematic ignoring, systematic ignoring with minimal check and systematic ignoring with parental presence were all evaluated as a treatment for infants with ISD. The key components investigated were the frequency of awakening and the duration of crying and it was found that all interventions resulted in a decrease in night wakings. This was supported by Wilson (2013) who found that when infants presenting with ISD were given the parental presence behavioural intervention, ISD behaviours decreased.

Decreasing infant sleep disturbance behaviours is not only beneficial for the infant themselves but also for parents. A meta-analytic review done by Kempler et al., (2016) on sleep interventions showed support for significant improvements in infant sleep as well as maternal post-natal depression. A study by Becker, Brazy and Grunwald (1997) found that coordinated and low stimulating care increases sleep consolidation and better defines the awake and sleep states in infants. This was further supported by Wilson (2013), who looked at three infants that presented with ISD. A parental presence behavioral intervention was implemented to assess the changes in sleep and the need for parental intervention. In this study it was found that infants sleep became more consolidated and there were fewer sleep-wake transitions, providing evidence that changing parental behaviours in regard to

infant sleep, resulted in increased self-soothing behaviours in infants which in turn increases self-initiation of sleep. This could indicate that over-stimulation from parents may have a correlation with undesirable behaviours (i.e. frequent awakenings, increased sleep onset delay and less self-soothing behaviour). Both studies suggest that a more coordinated and low stimulating ritual is beneficial and allows the infant to learn how to fall asleep and self sooth instead of relying on parent intervention to achieve these behaviours. This suggests that interventions aimed at increasing self-soothing behaviours are beneficial, as infants are able to re-initiate sleep and the need for external interventions from parent's decreases.

As shown above behavioural interventions increase infant sleep quality and decrease ISD behaviours such as night wakings and increased crying. They also show improvements in other aspects, such as parental psychopathology and stress.

Rationale

The development of healthy sleep-wake cycles in early infancy is important, as it has beneficial outcomes for both parents and infants themselves (Sadeh, 2005). The development and consolidation of sleep undergoes two major processes; the fragmentation of sleep improves, meaning there are longer sleep-wake cycles where more sleep occurs at night and more wake during the day. There is also a slow reduction of overall sleep, with increased wake times. These developments are important as literature suggests, sleep improves cognitive development in infants (Scher, 2005) and promotes healthy psychological growth for parents in regard to maternal mood, family stress and distress (Hiscock & Wake, 2002). Although the maturation of healthy sleep-wake cycles in infancy is considered typical development, when infants reach six months of age and are still exhibiting sleep behaviours which are needing constant nocturnal parental intervention

then this may be considered problematic (the development of ISD) and parents may choose to intervene.

Although temperament is assumed to be inbuilt, its expression may be influenced but not determined by the environment. For those infants who do continue to need parental intervention, research suggests that it may be in part due to their temperament (Kelmanson, 2004; Sorondo & Reeb-Sutherland, 2015) and having a difficult temperament may increase certain behaviours or qualities such as, increased crying, high irritability and low adaptability and mood (France & Blampied, 1999). There is however, some evidence that certain temperamental characteristics such as agreeableness improve in response to a sleep intervention (France, 1992). A limitation to current temperament research is that most of it is done with the implementation of perceived measures, which may become largely biased due to parental cognitions and perceptions, therefore the use of an objective measure such as negative emotionality is required to further our understanding.

Behavioural interventions which promote the implementation of low-stimulating bedtime routines are shown to decrease ISD (Wilson, 2013). This measured improvement in sleep poses questions about what has actually changed. When sleep patterns of infants are reported to have changed, is this a change in parent perception and reporting, or in infant behaviours related to entry into or exit from sleep, or a change in the structure of the sleep state itself (or any combination of these)? For example, does sleep lengthen? Are there fewer cycles? Does the proportion of REM versus NREM change? Or do the sleep problems become less evident (increased non-signalled awakening?) We do not know if it is a change in overt wakeful behaviour, self-soothing, self-regulation or a change in sleep structure itself or both. Furthermore, is there evidence of change in other, presumably inbuilt correlates of sleep, such as difficult temperament, here assessed objectively as negative emotionality?

Aims of the Current Research

Therefore, the current research poses the question does infant sleep quality and negative emotionality change after the implementation of a behavioural intervention? The aims of the current research are to see if the sleep patterns of infants with Infant Sleep Disturbance (ISD) aged 12-18 months change after a gradual behavioral intervention is implemented. Secondly to establish if sleep does change whether there is change in infant behaviours or a change in the structure of the sleep states? and thirdly to establish if negative emotionality, an objective measure and key aspect of temperament, changes at any point during the study and specifically in relation to any changes in sleep? The data analysis addresses the following research questions; firstly, was the gradual sleep intervention effective? Secondly, how did the sleep architecture and behaviours change? And thirdly how did negatively emotionality change throughout the study?

Method

Design

This study was a part of a larger study, “To intervene or not to intervene: Effects of behavioural sleep interventions on infant attachment quality” (Akdogan, 2018). This is described below.

A multiple baseline single case study design across participants was used. Participants were allocated to one of two groups namely intervention and comparison groups. These groups were dependent on the parental decision to implement a behavioural sleep intervention in the study or not. The intervention group received a behavioural intervention for ISD, whereas the comparison group received no intervention. The study provided the parents with options to which gradual sleep intervention was to be implemented. The options were extinction with parental presence and extinction with minimal check. Parents of Yvonne, Rebecca, Mike and Sherly chose the modified extinction with parental presence intervention and parents of Hamish and Wendy chose the modified extinction with minimal check intervention to implement. All families completed the four stages of this study; namely baseline, intervention, post-intervention and follow up phases. Participants in the intervention group were randomly assigned baseline lengths of 7, 14, 21 or 28 days and the comparison group provided sleep measures for the same duration. After the allocated length of time was completed for the baseline phase, the intervention phase was begun. The length of this phase for the intervention group was family dependent, each family continued in the intervention phase and filling out the sleep diaries for several weeks until the intervention outcome was satisfactory. The comparison group participants completed sleep diaries for 28 days in this phase. For the intervention and comparison groups, the third phase of the study (post-intervention) began three weeks after phase two

was completed. This had a duration of one week. The fourth and last phase was follow-up. This had a duration of one week for both groups and was completed 4 to six months after the first day of baseline.

Participants

Participants were nine healthy, typically developing infants between the ages of 12 and 18 months, recruited from the previous Canterbury Sleep Programme study described above. Six of the infants had completed an infant sleep programme prior to being recruited to this study and were put in the intervention group, where the remaining three participants were put into a comparison group. Inclusion criteria for all participants was a full 3 nights of VSM recordings at four time points, baseline, intervention, post intervention and follow up. Information about participants is summarised below in Tables 1a for intervention and 1b for comparison.

Table 1a. *Intervention participant information*

Participant Information (Intervention Group)							
Name	Age (Months)	Gender	Birth Order / Siblings	ISD (primary or secondary and age of onset)	Reported Sleep disturbances	Sleep Location	Previous Intervention attempts
Wendy	14	Female	1 st / 1	Primary ISD / 4 months	Night waking, Not re-settling, cosleeping	Cot in her own room + parents' bed	Yes – With professional Help
Hamish	11	Male	1 st / 1	Primary ISD / 6 months	Sleep onset delay, night waking, not re settling, cosleeping	Cot in his own room + parents' bed	Yes – without professional help
Yvonne	12	Female	1 st / 1	Primary / Birth	Night waking, Not re-settling, Cosleeping	Cot in her own room + parents' bed	Yes – With professional help
Rebecca	16	Female	2 nd / 2	Secondary	Night Waking, Not re-settling	Cot in her own room	Yes – With professional help
Mike	12	Male	1 st / 1	Secondary	Night Waking, Not Re-settling	Cot in his own room	No
Sherly	12	Female	1 st / 1	Primary / Birth	Night waking, not re-settling, cosleeping	Cot in her own room + Parents bed	No

Table 1b. *Comparison participant information.*

Participant Information (Comparison Group)							
Name	Age (Months)	Gender	Birth Order / Siblings	ISD (primary or secondary and age of onset)	Reported Sleep disturbances	Sleep Location	Previous Intervention attempts
Ben	13	Male	1 st / 1	Primary ISD / Birth	Night waking, Not re-settling, Sleep onset delay	Parents Bed	No
Scott	12	Male	1 st / 1	Primary ISD / Birth	Night waking,	Cot in parents' room	No
Peter	16	Male	1 st / 1	Primary / Since birth	Sleep onset delay Night waking, Night time settling	Cot in his own room + parents' bed	Yes – With professional help

Settings

Settings were limited to the participants' homes. For the intervention group, infants slept in their own cot in their own room, however for the comparison group, infants co-slept in either the parent's bed, or in their own bed with one parent. Consequently, full video data was more difficult to obtain for comparison group infants.

Apparatus

Videosomnography (VSG) was used to capture three nights of recordings for each infant, at four different time points. A D-Link HD Wireless N Cube (DCS2132L) Network camera was used with a Micro SD card for onboard storage. The camera was attached to a safe location with adhesive tape, so that the full view of the cot could be observed. The

camera was not put directly over the infant's cot however, due to safety concerns (i.e. earthquake). Recordings were programmed so they would automatically start at a predetermined time and stop 12 hours later. The time of the recording was decided, dependent on the typical sleep and wake time of each individual infant. The recordings were then transferred to an external hard drive for further analysis.

Measures

The changes to infant's sleep and temperament was measured through behavioral measures, which were completed by parents (i.e. sleep diary) and objective measures (i.e., VSG data and 15-minute interaction videos) which were to be analysed by the researcher.

VSG Data

Videosomnography (VSG) is a method used for recording and coding infant sleep patterns. Unlike other methods such as actigraphy and polysomnography, VSG can capture both signalled and non-signalled awakenings (Sitnick, Goodlin-Jones & Anders, 2008) as well as the sleep state of the infant (i.e. Active or Quiet sleep) and vocalisations. Gathering VSG data involves recording the infant from the time they are put down at night to the time they awake in the morning (Anders, 1979). This method also shows which interventions parents are using throughout the night as well as how long they are using them for (i.e. duration). VSG allows the researcher to view the infants sleep in their own home and in a natural setting as well as allowing researchers to observe sleep retrospectively (Anders, 1979).

Previous research using VSG (Gaylor, Goodlin-Jones, & Anders, 2000; Burnham, Goodlin-Jones, Gaylor & Anders, 2002) has documented the development of night wakings and self-soothing skills in infant sleep, they have also shown VSG to be a reliable and valid

method to implement. Therefore, because this method is able to detect both the silent and signalled awakenings coupled with parental interventions it provides a practical technique to assess whether sleep interventions are resulting in a change in sleep state, or sleep behaviours or a combination of these and hence was implemented to help answer the questions about infant sleep in this study.

The VSG data for this study was viewed at 8 times the original speed. After training from the supervisor, the researcher went on to code all videos. Training continued until the researcher was competent in the coding system. The coding method implemented was adapted from Anders (1979). The initial sleep state was coded by observing the infant's movements for the beginning three minutes of the VSG. Thereafter, the coding followed the classification described in detail below, in table 2. Every minute of the infant's sleep was assigned a code.

Table 2. *Classification table for coding infant sleep states*

Code	State	Description
1	Quiet Sleep	Characterised by the absence of body movement, Transition into this state requires no movements in a two-minute time period. This state continues, till an infant enters into another state. It is important to note that infants in this state do demonstrate occasional starts and movement, however if requirements of other states are not met, infants are recorded as being in a quiet sleep state.
2	Active Sleep	Characterised by sudden, involuntary, movement such as suckling. Transition into this state has a requirement of three movements within a five-minute time period, followed by one movement every two minutes.
3	Wake	Includes any amount of time the infant is clearly in an awake state (eyes open smooth voluntary movements)
4	Out of Cot	Includes any amount of time the infant is out of the cot (i.e. out of view)
5	Parental Intervention	Includes any amount of time the infant is engaged with parents

Parent Report Data

Sleep diaries were kept by parents throughout the whole study, which comprised 5-20 days in baseline, 4-6 weeks in the intervention phase, 5-7 days in the post intervention past and 5-7 days at 6 months follow up. The following information will be gathered from the sleep diaries; SOD, frequency and duration of night wakings, and parental intervention strategies that were used throughout the night.

Parental soothing strategies

Parental soothing strategies and techniques were coded in relation to a five-point scale developed by Tikotzky, 2009. Where five indicated the infant was nursing, feeding or being soothed by the parent, outside the crib or in the parent's bed, four indicated the infant was in the crib and was receiving parental intervention, three indicated the infant was in the crib and was receiving parental intervention however this lasted for less than two minutes (for example minimal check). Two indicated the infant was in the crib and although the parent was present there were no intervention strategies implemented, for example the parent was simply present with no touching or talking, and one indicated the infant was in the crib on their own without the caregiver.

Negative Emotionality Data

Negative emotionality of infants as measured in the NICHD Early Child Care Longitudinal Study in USA (NICHD, 1999) is an objective measure of difficult temperament (as defined by Chess and Thomas). As opposed to more frequently used perceived measures of temperament, negative emotionality is advantageous as it eliminates parental perceptions and views. Another advantage to this method is that infants are in their own

home environment and in a natural setting. Previous research using negative emotionality (Putnam, Sanson, & Rothbart, 2002; Sanson, Hemphill, & Smart, 2004) has found that negative emotionality (as a measure of difficult temperament) to be reliable and show important associations between both parenting and infant temperament characteristics.

Negative emotionality is measured through firstly recording a play session with the infant and then coding this session for certain behaviours. 15-minute video was recorded at each time point throughout the study. This recorded a play session where the mother was instructed to play with her child just as she would any other day. This video was then analysed to capture the following information; number of cries, number of fusses, number of rejecting mother's bids, number of throwing and hitting toys. The following will be totalled, and each infant's negative emotionality was rated on a scale from 1 to 4, at four different time points. This scale corresponds to the negative emotionality 4-point scale as measured in NICHD Early Childcare Longitudinal Study in the United States of America, where a score of one implied no sign of negative mood and a score of four implied a high level of fussiness and stress.

Procedure unique to this Study

Sleep State Coding

Each participant had a total of three nights of VSG data at four different time points. After initial training (by supervisor who had been trained by Anders at Brown University) the researcher continued on to code two out of the three nights for each participant at each phase. The first night of data was not coded (due to the infant becoming accustomed to the camera). Videos were taken at the middle of each phase. The researcher viewed the videos at eight times the original speed and coded each state as it was viewed with frequent stops

to check and review footage at slower speeds. In terms of parental intervention, both the duration and techniques were noted. When parental intervention occurred, the video was slowed down to get the precise duration that it occurred for, during this time the different techniques parents used were also noted when visible. Techniques included but were not limited to rocking, patting, taking the infant out of the cot, and/or holding. A total of 72 videos were coded.

Coding Analysis

Once video coding was completed the researcher continued on to analyse the sleep state data. It was decided the following dependent variables would be calculated, total sleep time, percentage of quiet sleep (also allows a percentage of REM/active sleep to be calculated) , longest sleep period, longest self-regulated sleep period, sleep onset delay, night waking duration, night waking frequency, number of sleep-state transitions, number of sleep-wake transitions, sleep efficiency, REM tolerance and parental intervention techniques. These are operationalised in table 3. These factors were coded individually and then by averaging the variables across the two nights for each phase, for each individual. Meaning in terms of night waking when the number was 1.5, it corresponds to the average over the two nights.

Table 3. *Definitions of Variables*

Total sleep time	Total time asleep was the total duration of sleep from the start of the night till the infant was awake in the morning.
Percentage of quiet sleep (also allows a percentage of REM sleep to be calculated)	The percentage of quiet sleep was total sum of every quiet sleep coding from the videos, divided by the total sleep time. The remaining percentage allows the active/REM sleep to be calculated.
Longest sleep period	The longest sleep period is the longest period the infant is in a sleep state throughout the night (i.e. sleep without wake), for each night there is only one longest sleep period.
Longest self-regulated sleep period	The longest self-regulated sleep period is the longest sustained period of sleep with quiet awakes, for example it is the longest time the infant went without signalling (one period for each night).
Sleep onset Delay	Sleep onset delay is the period from when an infant is in their cot to the time the infant is asleep.
Night waking duration s	Night waking durations were the total time the infant was awake in one awake period. For each night waking frequency there will be a night waking duration.
Night waking Frequency	Night waking frequency, this was the number of times the infant awoke at night (both signalled and silent awakenings were included).
Number of sleep-state transitions	The number of sleep state transitions were the number of times the infant changed sleep states without an awake period. For example, if an infant awakes every time there is a transition then the number for that night would be zero.
Number of sleep-wake transitions	The number of sleep-wake transitions were the number of times the infant changed from an awake to a sleep (either active or quiet) state.
Sleep Efficiency	Sleep efficiency refers to the duration of time spent asleep when an infant has the opportunity to do so (i.e. the time spent asleep from when an infant is put down in their cot to when they are taken out in the morning).
REM Tolerance	REM tolerance refers to the number of times the infant sustained REM sleep, meaning the number of times they slept through REM without waking up.
Parental Interventions	What type of intervention the parent is using, i.e. rocking. Feeding

Results

This section is structured in the following way. Firstly, the use of modified Brinley plots and the quality of the data is discussed. Secondly parental behaviours in the intervention group are examined. Thirdly, if and how the infants' sleep problems changed in response to the intervention, based on sleep diary, will be examined and fourthly, changes in sleep-state organisation from VSG data will be presented. Finally, negative emotionality scores are examined for changes in response to the intervention.

Modified Brinley Plots

Data analysis was done with the implementation of modified Brinley plots. Figure 1 shows a description of modified Brinley plots. Unlike standard scatter plots where the correlation of different dependent variables is shown, modified Brinley plots show the same dependent variables plotted for participants over pairs of time (Blampied, 2017). This shows individual change over a period of time, while also showing change in others, allowing comparisons to be made.

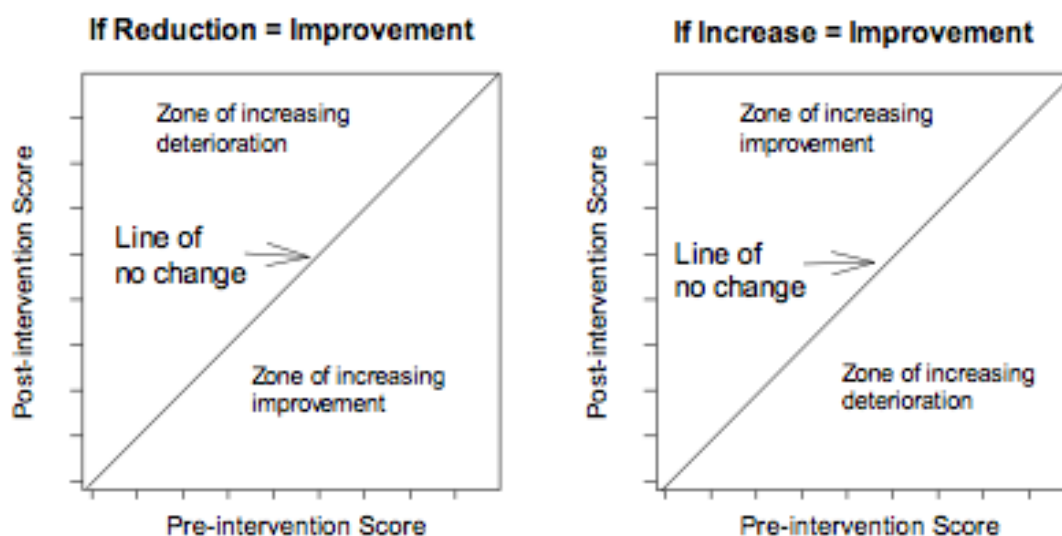


Figure 1. *Description of modified Brinley Plots*

Quality of the Data

The quality of data for the nine participants was high. In regard to the VSG data, all but one participant (Sheryl) had two nights of recording for each phase of this study. Sheryl had missing VSG data for three post intervention phase variables of this study. All participants had a 15-minute play interaction recorded at all four-time phases for the negative emotionality data to be analysed.

Reliability

Reliability for parent report sleep diaries against the VSG data, as well as the reliability of the VSG coding was calculated.

Reliability between parent report sleep diaries and VSG data.

Table 4 shows the overall reliability between parental sleep diaries and VSG data for both groups on the following factors, namely what time the infant was placed in the cot at night, what time the infant was taken out of the cot in the morning, the number of signalled awakenings and the duration of each individual awakening. Reliability was between 80% and 100% which indicates good reliability of parental report data.

Table 4. *Reliability of parent sleep diary data and VSG data*

	Intervention	Comparison
In cot at night	96%	81%
Out of cot in the morning	92%	86%
Signalled Night Awakening	100%	100%
Duration of Single Night Awakening	82%	80%

Reliability of VSG coding

Reliability for VSG coding was measured with a second rater. One quarter of the videos were randomly chosen for reliability checking, with both coders trained to use the original coding system (reported in the method). A total of 16 videos were coded for reliability across the two coders, with a reliability score of 85%-98%.

Parental Soothing

Figure 24 shows the changes in parental soothing from baseline to intervention and from baseline to post intervention for both groups. Figure 25 shows these changes at follow-up.

In the intervention group from baseline to the intervention phases, Mike, Rebecca and Wendy's parent decreased their parental soothing behaviours, Hamish's parents increased slightly, and both Sheryl and Yvonne's parents remained the same. At the post intervention phase, these trends continued. At follow up all parents of participants had decreased in their soothing behaviours however Yvonne's parents remained the same.

In the comparison group from baseline to intervention Peter's parents decreased in their parental soothing behaviours and both Ben and Scott's parents remained the same, this was also evident at the post intervention phase. At follow-up Peter and Ben's parents had decreased in their soothing behaviours and Scott's parents remained constant.

Parental Soothing

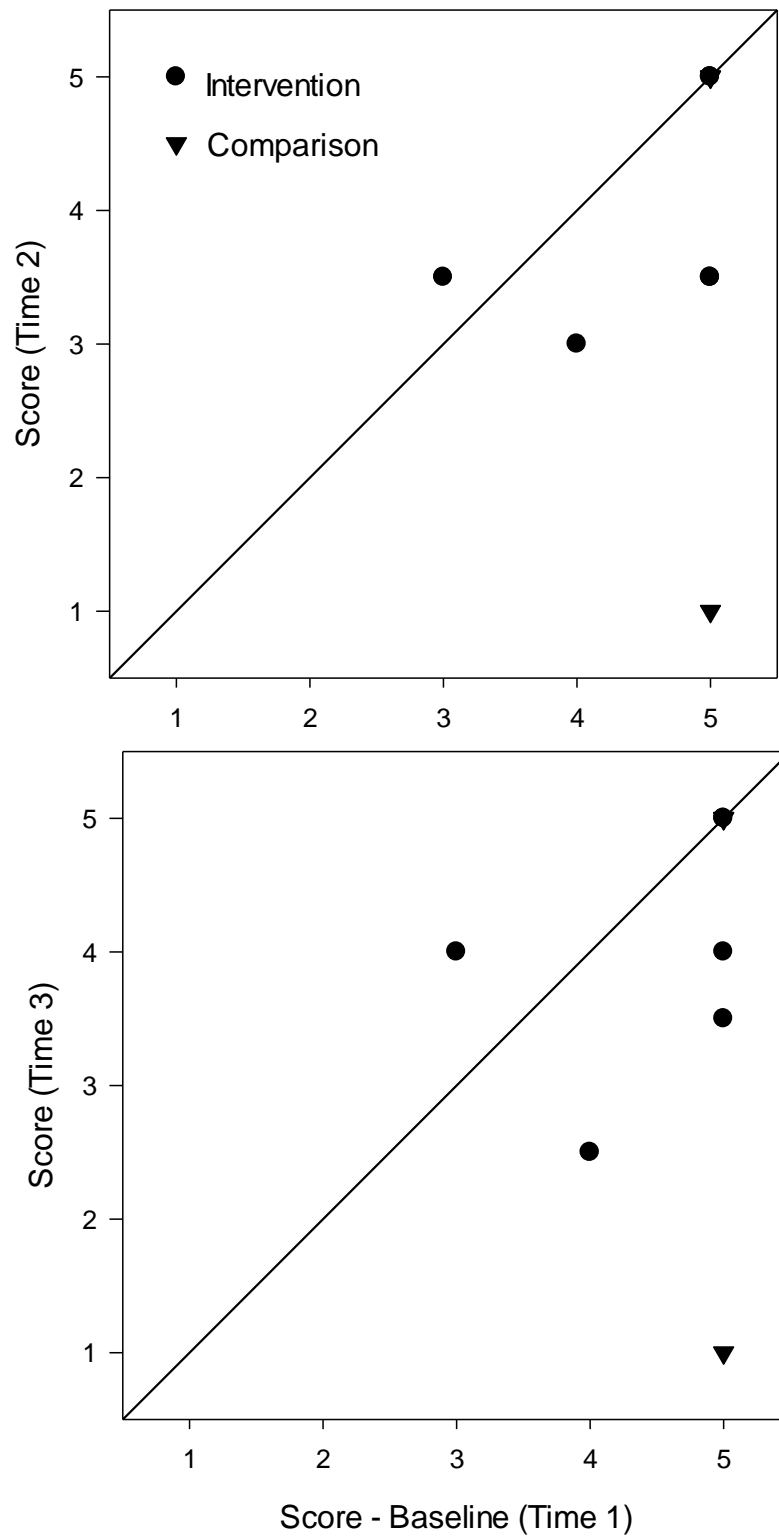


Figure 24. VSG data and Sleep Diary data for Parental Soothing

Parental Soothing- Follow-up

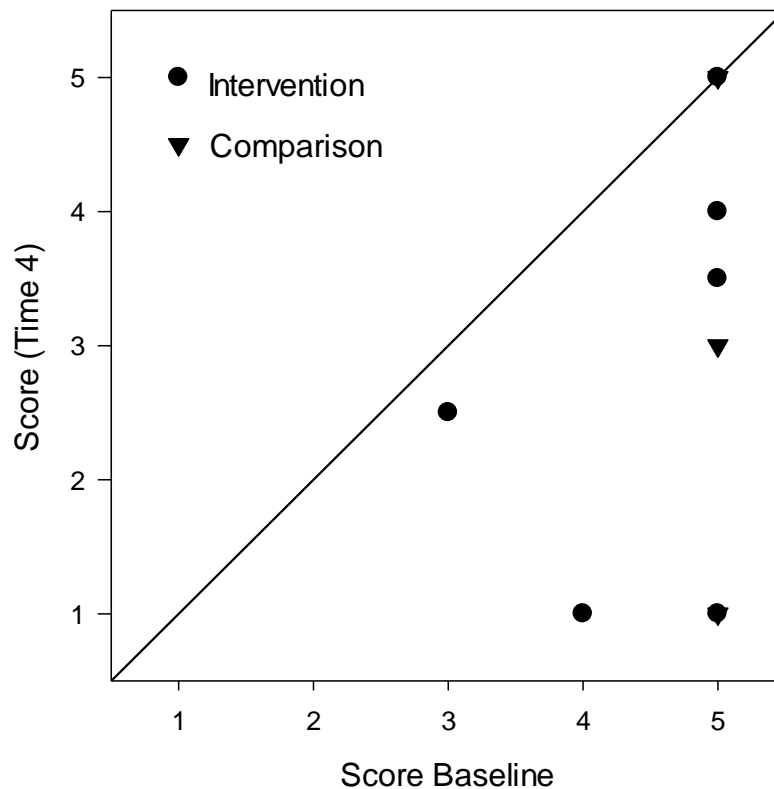


Figure 25. VSG data and Sleep Diary data for Parental Soothing at follow-up

Infant sleep change in response to intervention

Participants in the intervention group would show a treatment effect through one or more changes in the following measures, namely a decrease in sleep onset delay, a decrease in signalled night wakings, and/or a decrease in the duration of signalled night wakings.

SOD results need to be interpreted cautiously. An increase in SOD could be due to change in parent behaviour resulting from the intervention being implemented correctly.

These variables were analysed using the parental report sleep diary data and modified Brinley plots were formed. Time two refers to the intervention phase, time three refers to the post intervention phase and time four is the follow-up phase.

Sleep onset delay (SOD)

Figure 2 shows the sleep onset delay from baseline to intervention and baseline to post intervention. In the comparison group all participants improve SOD, Peter decreases his SOD from 5 minutes to no SOD, Ben decreases his SOD by almost half the duration (from 54 minutes to 23 minutes) and Scott still shows no SOD. For the intervention group there appears to be change in half of the participants. Hamish, Sheryl and Wendy all decrease their SOD and Mike, Rebecca and Yvonne all increase their SOD by varying durations. This increase in SOD at this time period could be due to the intervention being implemented and parental behaviours changing. If infants were breastfed to sleep and this behaviour changes due to the intervention, this could cause an initial increase in SOD.

Looking now at the SOD from baseline to post intervention for the comparison group, Peter and Ben decrease their SOD and Scott still shows no SOD. For the intervention group Rebecca increases her SOD, Hamish, Mike and Wendy remain relatively the same, Sheryl and Yvonne decrease their SOD.

Figure 3 shows the SOD from baseline to the follow up phase for both the intervention and comparison groups. For the intervention group, only Yvonne and Sheryl decrease in their SOD and all other participants increase at varying durations. For the comparison group at follow up Peter shows an increase in SOD, Ben remains decreased and Scott has no SOD. In summary, for the intervention group Sheryl and Yvonne show a clear treatment effect with their SOD decreasing. Mike and Wendy go back to having no SOD after initially increasing at intervention. Hamish increases only slightly (2 minutes) and Rebecca has a larger increase in her SOD duration. In the comparison group, infants decreased in SOD. The SOD is therefore, variable for reasons other than the intervention, for example an increase may indicate more independent settling.

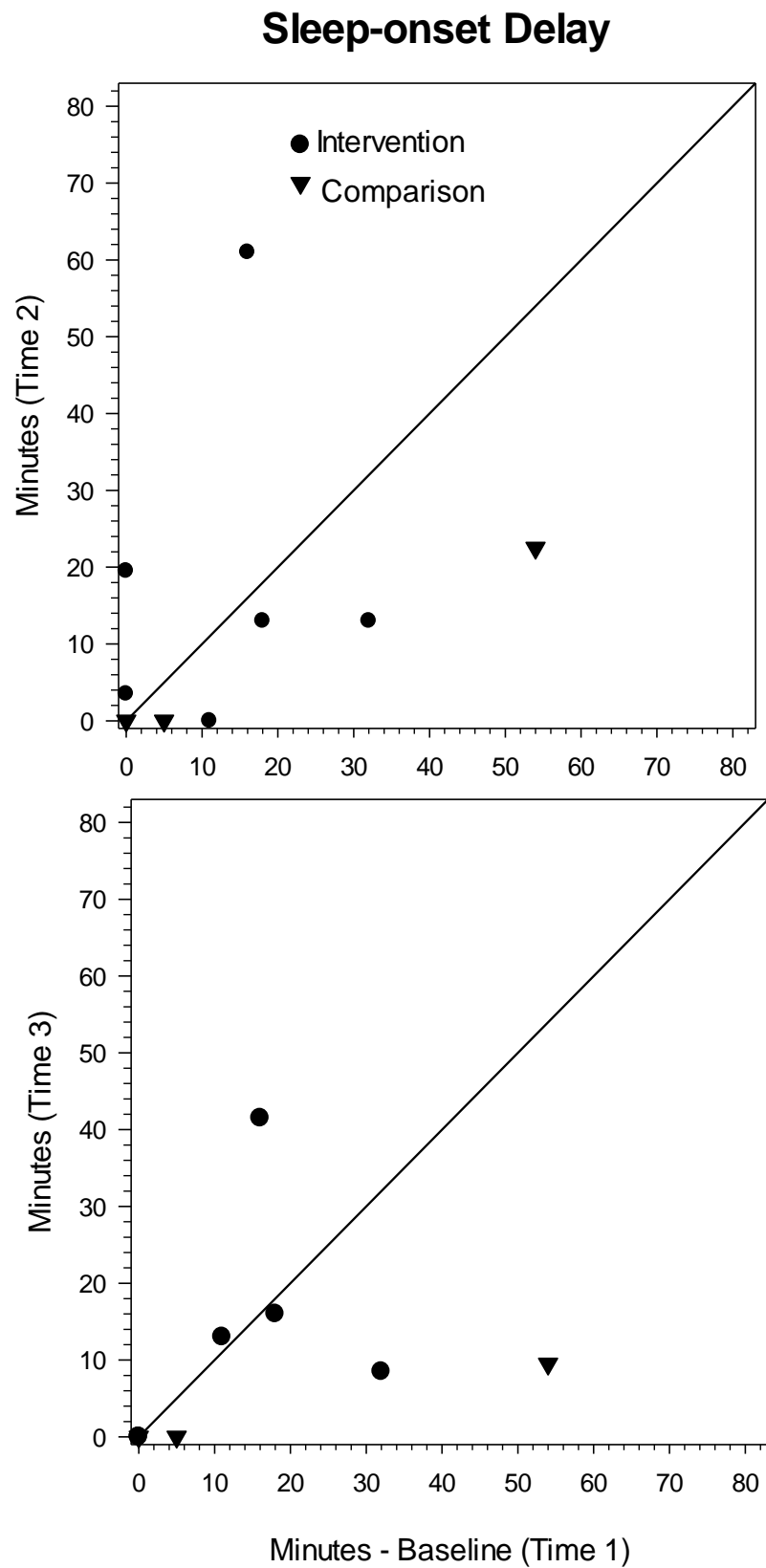


Figure 2. Sleep Diary Data for Sleep Onset Delay

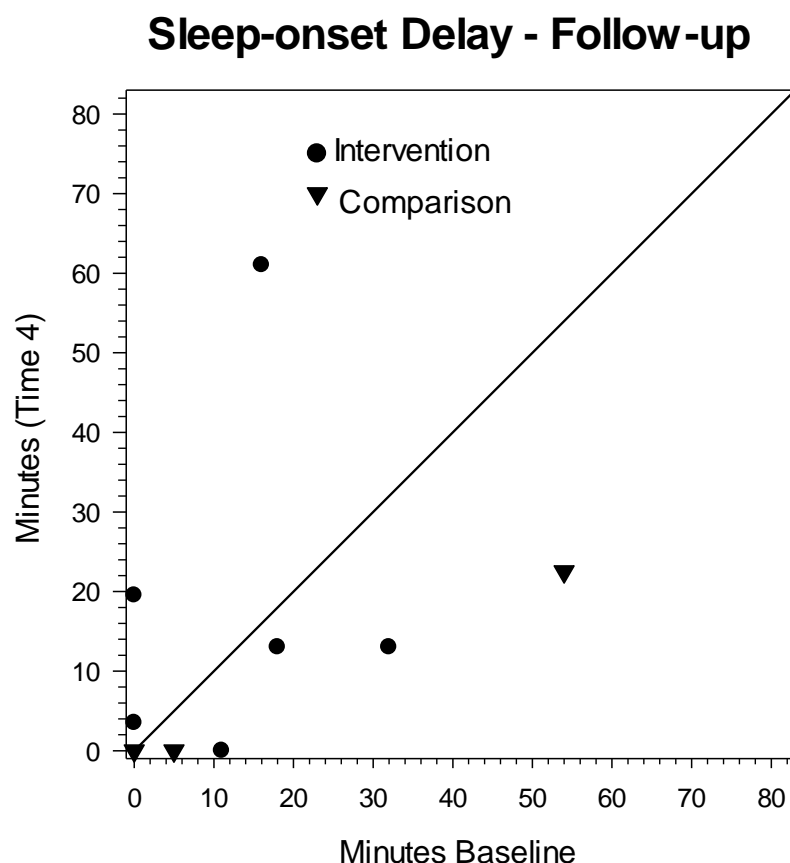


Figure. 3 Sleep Diary Data for Sleep Onset Delay at Follow-up

Signalled Night Waking Frequency

Figure 4 shows the signalled night waking frequency from baseline to intervention and baseline to post intervention. Figure 5 shows signalled night waking frequency at the follow up phase. There appears to be a consistent decreased trend with all infants in both the intervention and comparison group but Rebecca (intervention group). Rebecca appears to increase slightly, going from an average of one-night waking to one and a half night wakings. However, in the post intervention phase all participants (both intervention and comparison groups) remain consistent and show a decrease in the number of night wakings. At follow up this change is still consistent for intervention group participants; Hamish, Sheryl, Wendy and Yvonne, with Mike and Rebecca showing slight increases from their baseline numbers.

In the comparison group Peter remains the same as baseline, Ben decreases slightly, and Scott increases slightly.

In summary, from baseline to post intervention all participants, in both the intervention and comparison group, decreased in the number of night wakings. Therefore, showing a treatment effect of the intervention for Hamish, Mike, Rebecca, Sheryl, Wendy and Yvonne. The treatment effect was still apparent at follow up for all except Mike and Rebecca. In terms of the comparison group this decrease in the number of night wakings may indicate developmental change.

Night Waking

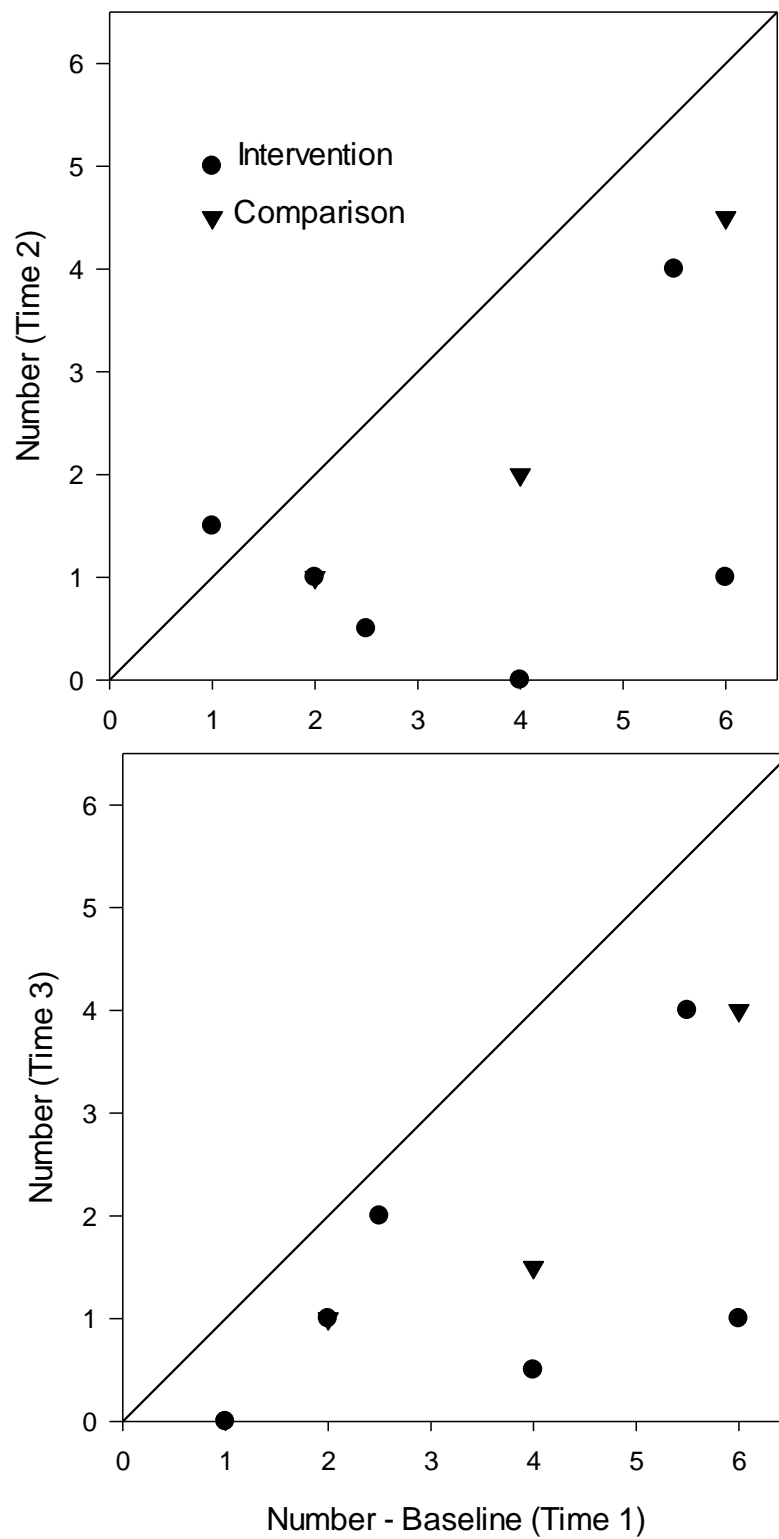


Figure 4. Sleep Diary Data of Signalled Night Waking Frequency

Night Waking - Follow-up

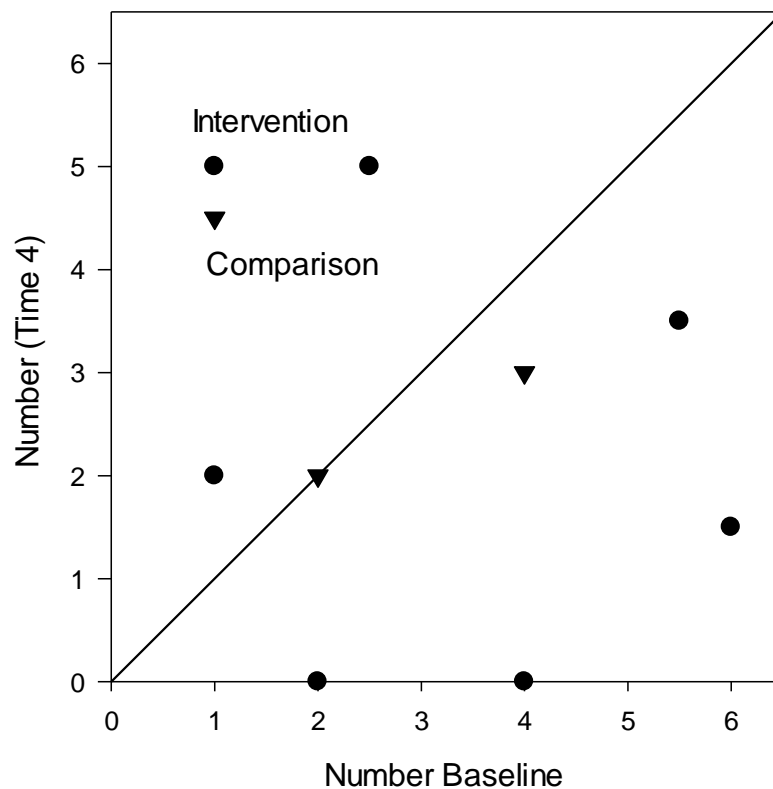


Figure 5. Sleep Diary Data of Signalled Night Waking Frequency at Follow Up

Signalled Night Waking Duration

Figure 6 shows the duration of signalled night wakings from baseline to intervention and from baseline to post intervention. Figure 7 shows the duration of signalled night wakings from baseline to follow-up. From baseline to the intervention phase for the intervention group, Hamish, Rebecca, Sheryl, and Wendy, all decreased their night waking duration. Mike and Yvonne both appeared to increase by a large amount, with Mike going from an average of 7.2 minutes to 75 minutes and Yvonne going from an average of 15.5 minutes to 33.5 minutes. What is interesting to note here is that although Rebecca had a reduction in her night waking duration from baseline to intervention phases, she had an increase in her night waking frequency (Figure 4). This trend was not consistent at the post

intervention phase in these participants. While Rebecca and Yvonne showed a decrease in their night waking duration, Hamish, Mike, Sheryl and Wendy all increased from baseline to post intervention. At follow-up night waking durations changed once again, at this time phase, Rebecca, Sheryl, Wendy and Yvonne all decreased and Mike and Hamish increased.

For the comparison group, Ben and Scott decreased their night waking duration and Peter showed an increase. These results remained fairly consistent at both post intervention and follow up phases, with Peter showing more of an increase in duration.

In summary, there appears to only be a treatment effect of the intervention for Rebecca and Yvonne at the post intervention phase for signalled night waking duration. This treatment effect is still evident for Rebecca and Yvonne at follow up. For the comparison group results are variable, with Peter increasing consistently and Ben and Scott both decreasing.

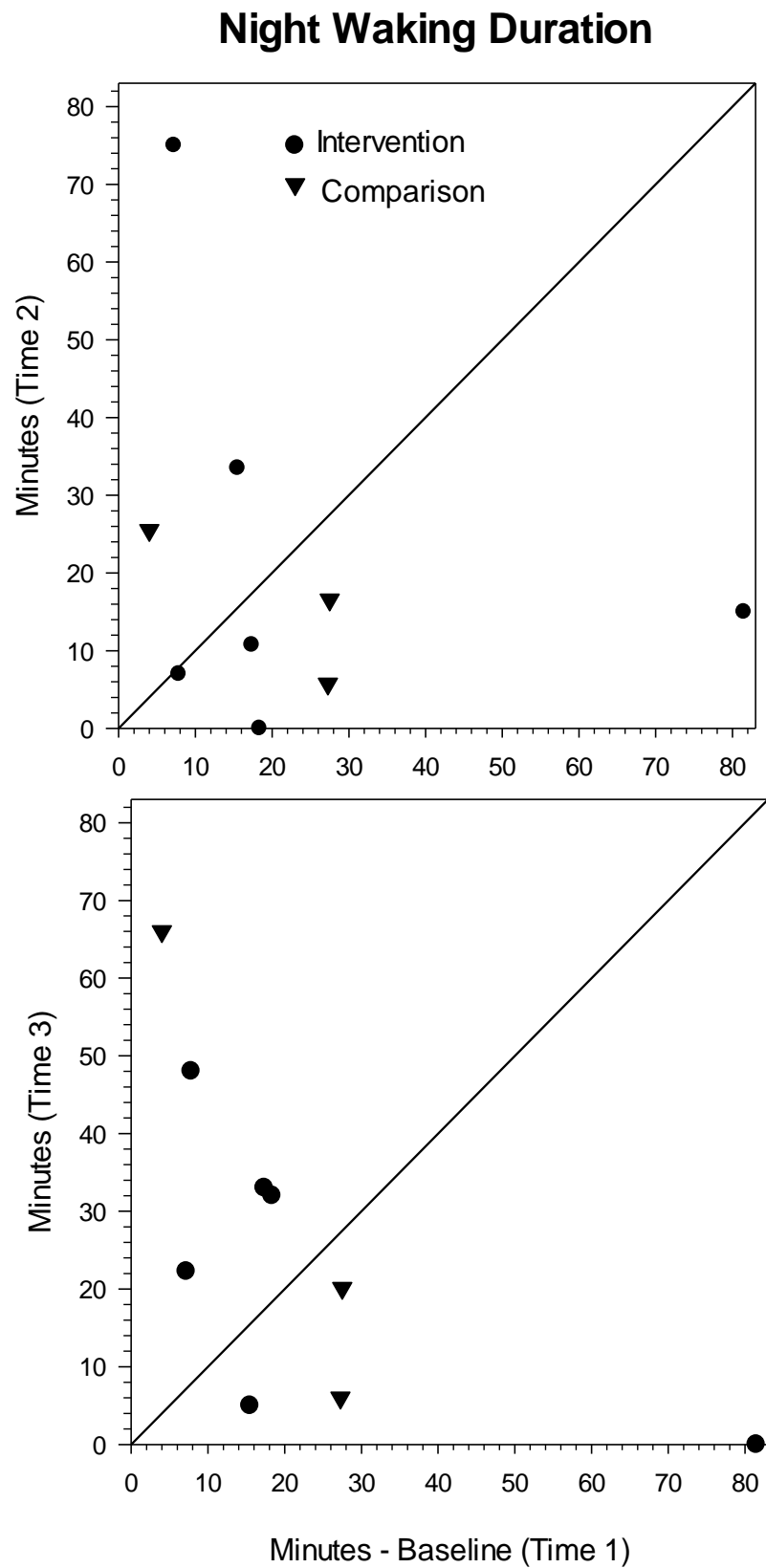


Figure 6. *Sleep Diary Data of Signalled Night Waking Duration*

Night Waking Duration - Follow-up

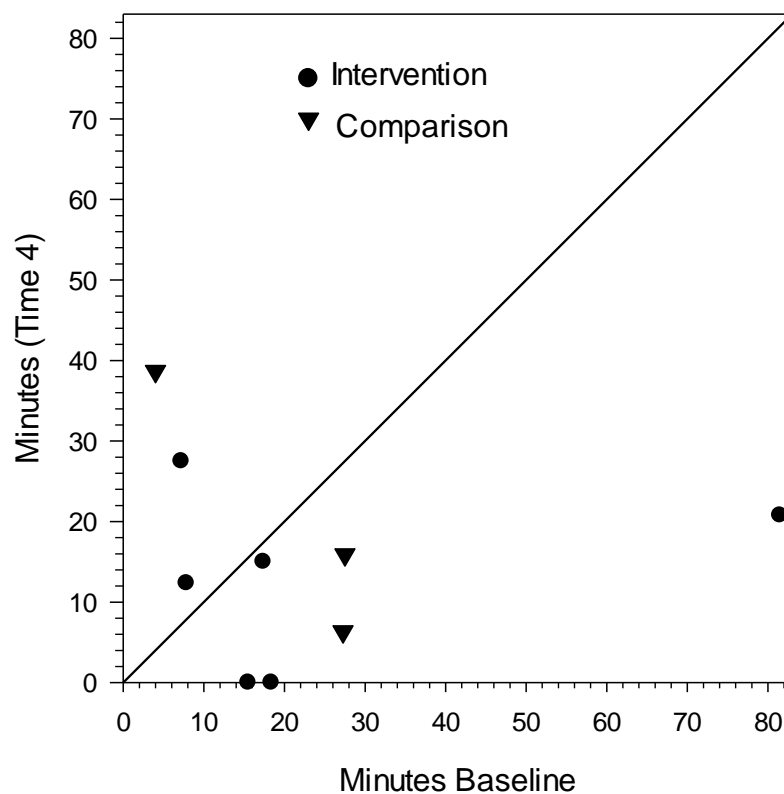


Figure 7. *Sleep Diary Data of Signalled Night Waking Duration at Follow-up*

Summary: Intervention Effect

In summary, for the intervention group the results show that infants responded differently to the intervention. It is important to note that although Rebecca and Yvonne are the only participants in the intervention group that decreased their duration of night waking at post intervention, the frequency of night wakings, for all intervention participants decreased. This suggested that Hamish, Mike, Sheryl and Wendy may have been waking less, but these wakings were lasting for longer periods of time. For the comparison group the data was also variable and did not show consistent changes.

Variability in the data resulting from the limited data points available does mean conclusions were hard to draw. Therefore, data, from the original study (Akdogan, 2018),

and based on full diary data for all intervention and comparison participants, was considered and is summarised in the first 3 columns of Table 5. This indicates that for all the intervention infants, results were in the expected direction. That is, intervention parents responded less (column 12, Table 5), and their sleep problems changed accordingly (see Table 5). The percentage deviating from the Median (PEM) for comparison participants is not available but visual analysis of the data paths indicated how the infants responded to each of the variables. This is also shown in Table 5.

Table 5. Sleep information for infants in both Intervention and Comparison groups

	Number of Night Wakings ↓	Duration of Night Wakings ↓	Percentage of the target duration of total sleep	Total Sleep Time ↑	Percentag e of quiet sleep ↑	Sleep Efficiency ↑	LSP ↑	LSRSP ↑	Sleep- Wake ↓	Sleep- State ↓	REM Tolerance ↑	Parental Soothing Scale ↓
Intervention												
Wendy	94	100	97	Decrease	Increase	Increase	Increase	Increase	Decrease	Increase	Increase	Decrease
Hamish	100	67	80	Decrease	Increase	Increase	Increase	Increase	Decrease	Decrease	Increase	Decrease
Yvonne	97	97	91	Increase	Increase	Increase	Increase	Increase	Decrease	Increase	Increase	Constant
Rebecca	96	96	88	Increase	Decrease	Increase	Increase	Increase	Decrease	Increase	Increase	Decrease
Mike	87	72	72	Increase	Increase	Decrease	Decrease	Decrease	Increase	Increase	Decrease	Decrease
Sheryl	95	81	97	Increase	Increase	Increase	Increase	Increase	Decrease	Decrease	Increase	Decrease
Comparison												
Ben	No Change	Decrease	No Change	Decrease	Increase	Increase	Decrease	Decrease	Decrease	Decrease	Decrease	Constant
Scott	No change	Increase	No Change	Decrease	Decrease	Increase	Decrease	Decrease	Decrease	Increase	Increase	Constant
Peter	Decrease	No change	No Change	Decrease	Increase	Decrease	Increase	Increase	Decrease	Decrease	Decrease	Decrease

Note: Arrows in the headings indicate direction of expected effect for sleep improvement. Bold increase/decrease indicates the expected direction of change is shown.

Changes in Sleep-State Organisation

Measures of sleep states were taken using VSG, at four time points for all participants, namely in baseline, intervention, post-intervention and at follow up. The following variables were measured from this data: total sleep time, percentage of quiet sleep, duration of awakenings (both silent and signalled), sleep efficiency, LSP, LSRSP, sleep-wake transitions, sleep-state transitions, REM tolerance and parental intervention techniques that were used. These are shown below in modified Brinley plots.

Total Sleep Time

Figure 8 shows the total sleep time of each group (intervention and comparison) between baseline and intervention, and baseline and post intervention. Figure 9 shows the total sleep time at follow-up.

For the intervention group, from baseline to the intervention phase Rebecca, Sheryl, Wendy and Yvonne increased in their total sleep time, Mike decreased, and Hamish appeared to remain the same. From baseline to post intervention phase, Mike, Rebecca, and Yvonne showed an increase in their total sleep time, and both Hamish and Wendy showed a decrease in total sleep time. Sheryl had missing data at this phase for total sleep time. At the follow up phase, Hamish and Mike decreased, Rebecca, Sheryl and Yvonne increased, and Wendy stayed relatively the same.

For the comparison group from baseline to intervention Scott increased his total sleep time, however both Peter and Ben showed a decrease in their total sleep time. From baseline to the post intervention phase Scott increased his total sleep time even further, however both Ben and Peter still appear to have a decreased total sleep time. At follow-up all participants have decreased their total sleep in this group, from baseline.

In summary, Mike, Hamish and Wendy do not show consistent trends in their total sleep time. However, Rebecca, Sheryl and Yvonne all increase consistently throughout the phases and in the comparison group, all infants had a decreased total sleep time at follow up.

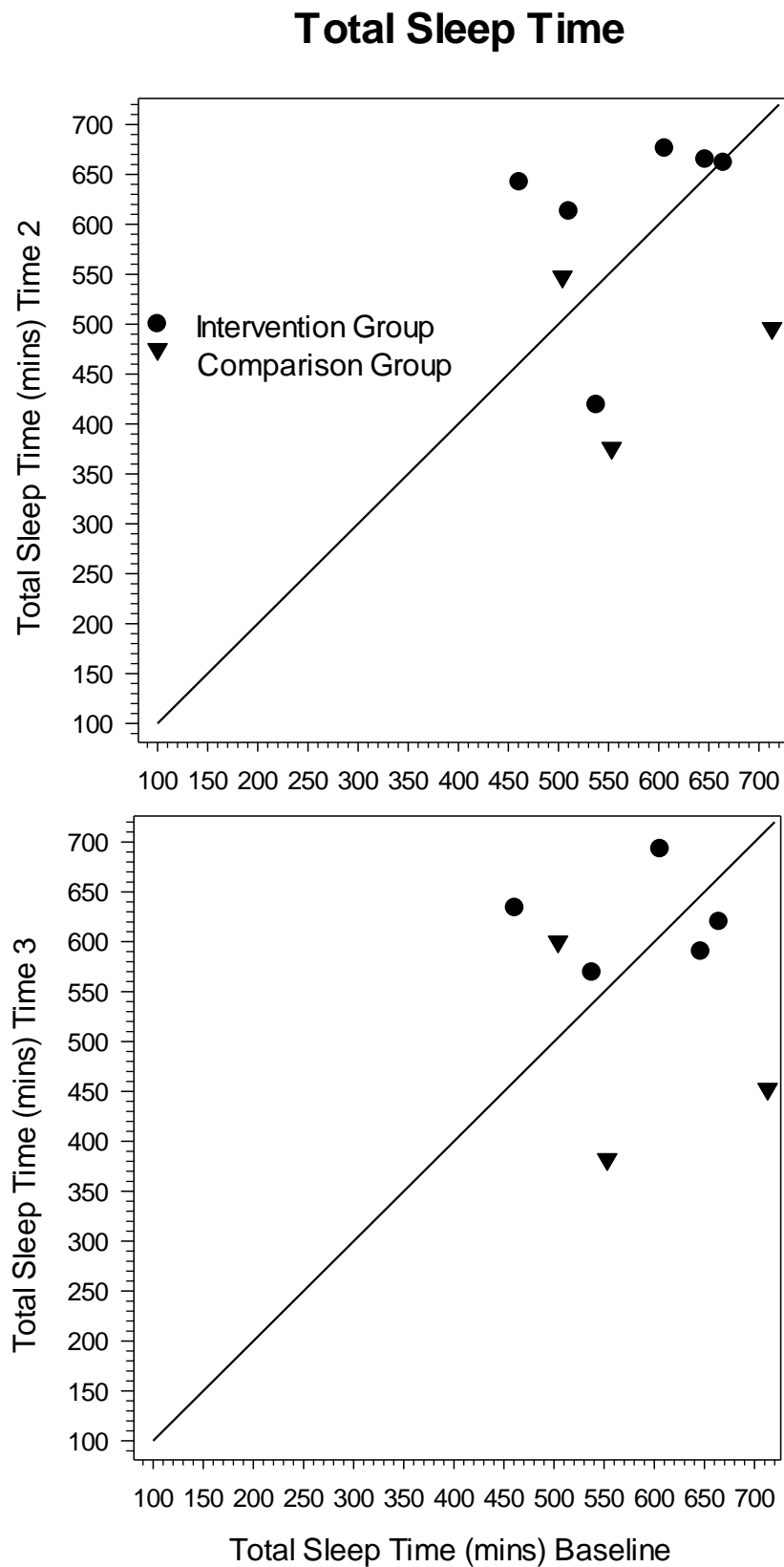


Figure 8. VSG data for total sleep time

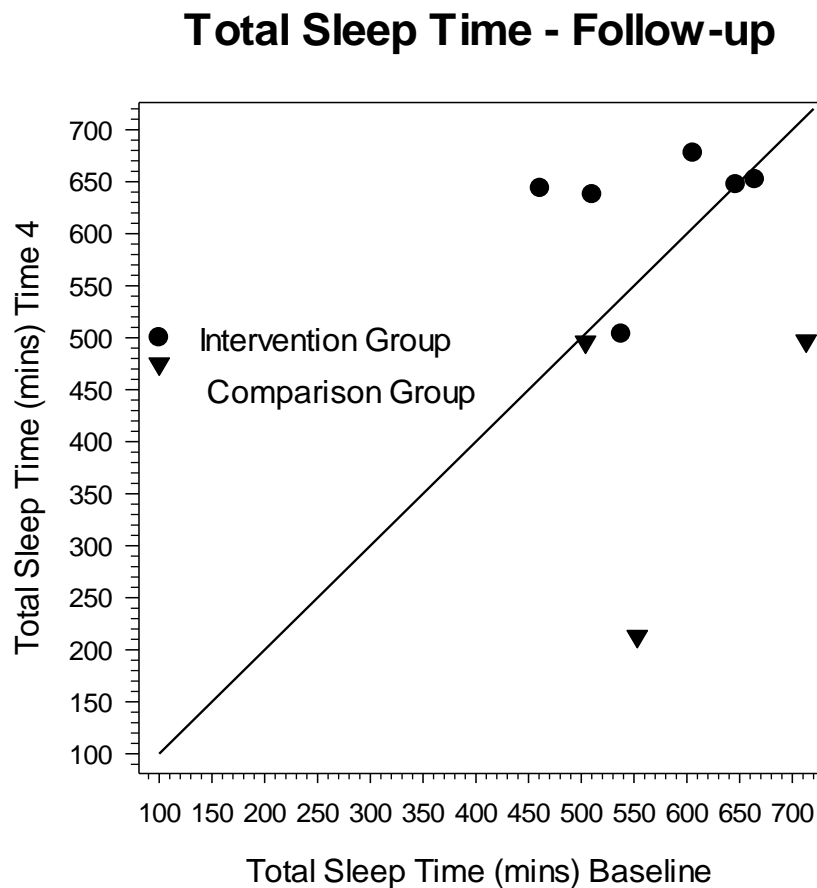


Figure 9. VSG data for total sleep time at follow-up

Percentage Quiet Sleep

Figure 10 shows the percentage of quiet sleep between baseline and intervention, and baseline and post intervention. Figure 11 shows the follow-up data for this variable.

For the intervention group, from baseline to intervention Mike, Sheryl, Wendy and Yvonne all had an increased amount of quiet sleep, Hamish decreased only slightly (2 minutes) and Rebecca decreased to a greater extent (from 76 minutes to 40 minutes of quiet sleep). At post intervention, Hamish showed an increase and the other participants remained consistent, (Sheryl had missing data at this phase). At follow-up Hamish went back to baseline percentage, Rebecca and Yvonne decreased and the others all increased.

In the comparison group, from baseline to intervention Peter and Ben showed an increase in their quiet sleep and Scott showed a decrease. These trends were consistent at the post intervention phase. At follow-up Peter decreased his percentage of quiet sleep while Ben and Sheryl increased.

In summary, the percentage of quiet sleep increased for all participants following intervention, except Rebecca (who decreased in quiet sleep percentage). For the comparison participants, percentage of quiet sleep did not show consistent change, with two participants (Ben and Scott) increasing and the other (Peter) increasing.

Percentage Quiet Sleep

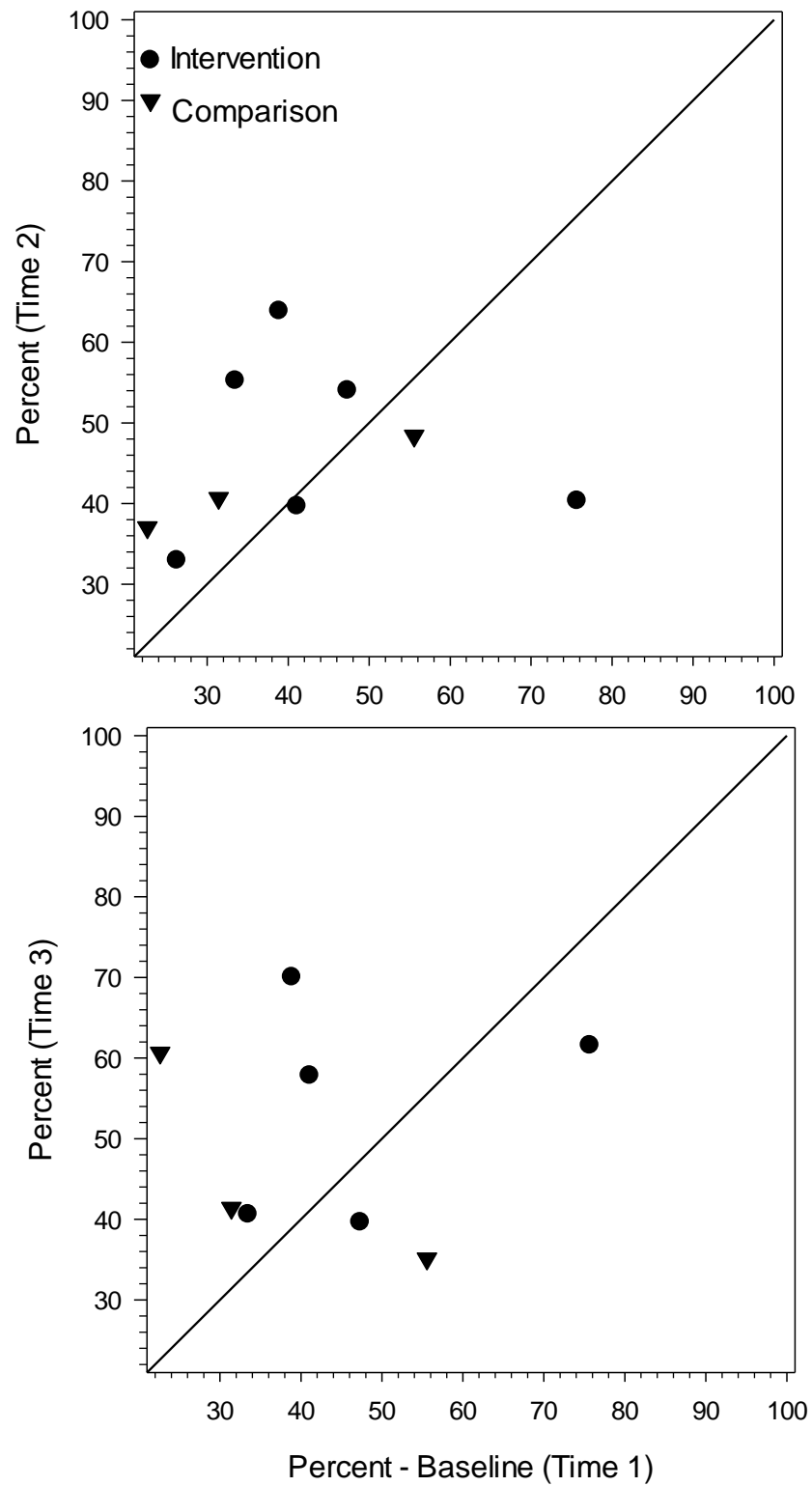


Figure 10. VSG data for percentage of quiet sleep

Percentage Quiet Sleep - Follow-up

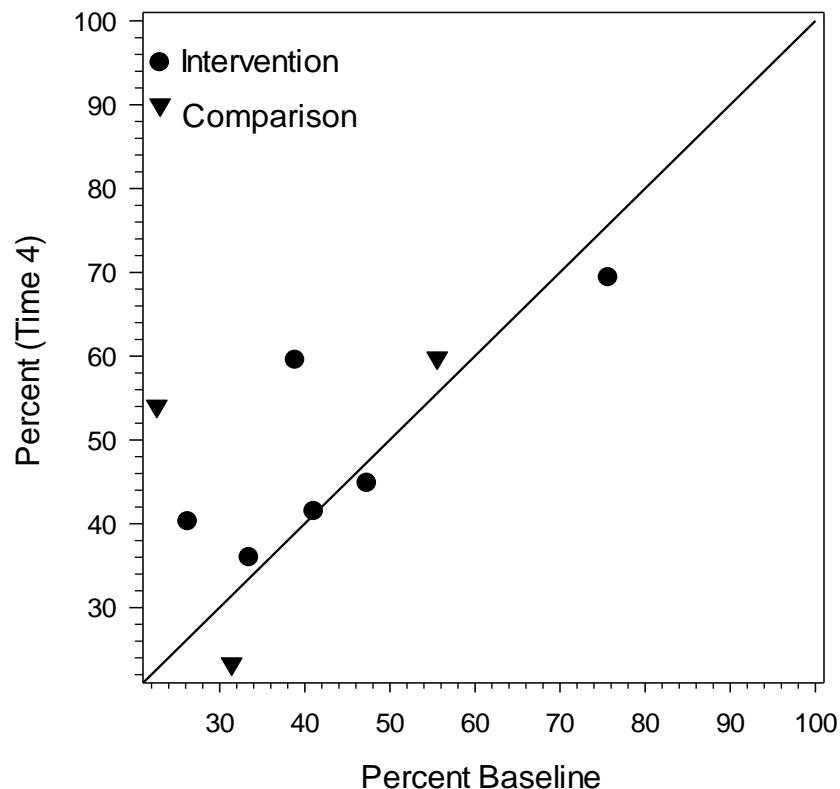


Figure 11. VSG data for percentage of quiet sleep at follow-up

Sleep Efficiency

Figure 12 shows the sleep efficiency between baseline and intervention, and baseline and post intervention for all participants. Figure 13 shows the follow up data for sleep efficiency. From baseline to intervention Hamish, Rebecca, Sheryl, Yvonne and Wendy all increased in their sleep efficiency and Mike slightly decreased (by 2 minutes). In the comparison group, both Ben and Scott increased from baseline to intervention and Peter decreased in his sleep efficiency. This remained consistent from baseline to post intervention for both the intervention and comparison groups, however Peter showed a further decrease in sleep efficiency. At follow up, all intervention group participants increase except Mike who continues to show a decrease in sleep efficiency. For the

comparison group at follow up Peter decreases and both Ben and Scott increase their sleep efficiency.

In summary, these results suggest that for the intervention group, participants increased in their sleep efficiency during and after the intervention phases, meaning they spent a larger proportion of their time in bed, asleep as opposed to awake, these changes were sustained at the follow-up phase for all participants except Mike, who continually decreased in sleep efficiency. For the comparison group, two of the three participants increased, and Peter decreased.

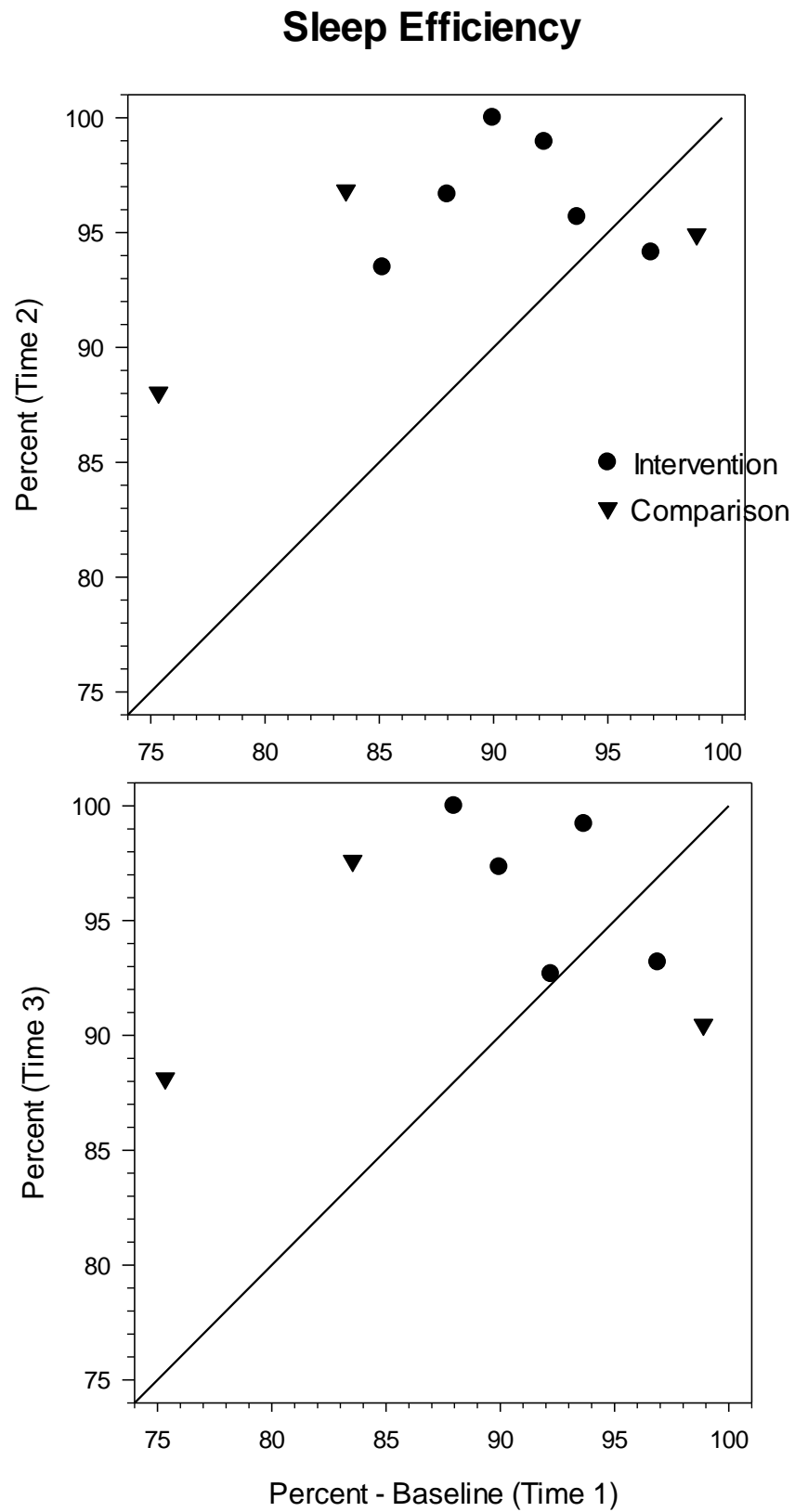


Figure 12. VSG data for Sleep Efficiency

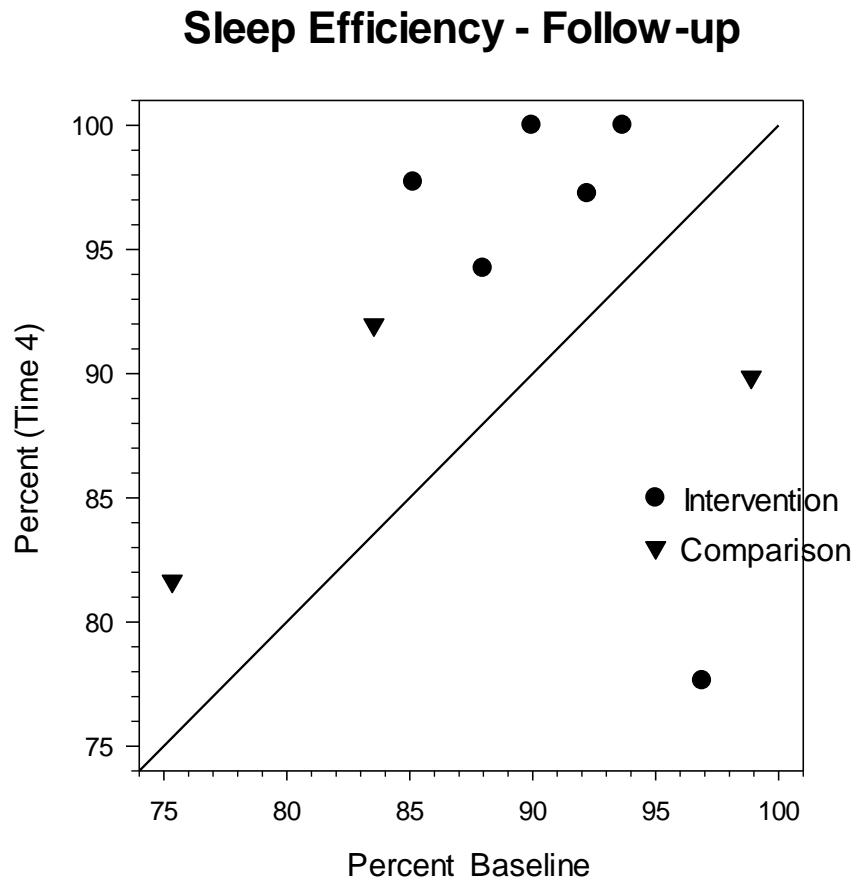


Figure 13. VSG data for Sleep Efficiency at follow-up

Longest Sleep Period (LSP)

Figure 14 shows the LSP from baseline to intervention and from baseline to post intervention for both the intervention and comparison groups. Figure 15 shows the follow-up data for LSP. For the intervention group, from baseline to intervention Hamish, Rebecca, Sheryl, Wendy and Yvonne all showed an increase in their LSP. Mike decreased in his LSP, going from 407 minutes to 389 minutes on average. From baseline to post intervention, these trends were constant for all participants except Sheryl, who showed a decrease in her LSP. At follow up these changes are sustained for all participants except for Sheryl who increases her LSP duration (higher than baseline duration).

In the comparison group, both Peter and Scott showed an increase and Ben decreased. At post intervention Peter continued to increase and both Scott and Ben decreased in their LSP. At follow up, these results are constant, with Peter showing a further increase in his longest sleep period and both Ben and Scott showing further decreased periods.

In summary, for the intervention group these results imply that Hamish, Rebecca, Yvonne and Wendy could sleep for a longer period of time in the night without an awake period, suggesting that sleep consolidation was occurring. Although Sheryl initially increased in her LSP in intervention, she then decreased at post intervention (from 202 minutes at baseline to 171 minutes at post intervention) followed by another increase in duration (208 minutes). Mike shows a consistent decrease in this LSP. For the comparison group, only Peter increases while both Ben and Scott decrease in their LSP.

Longest Sleep Period

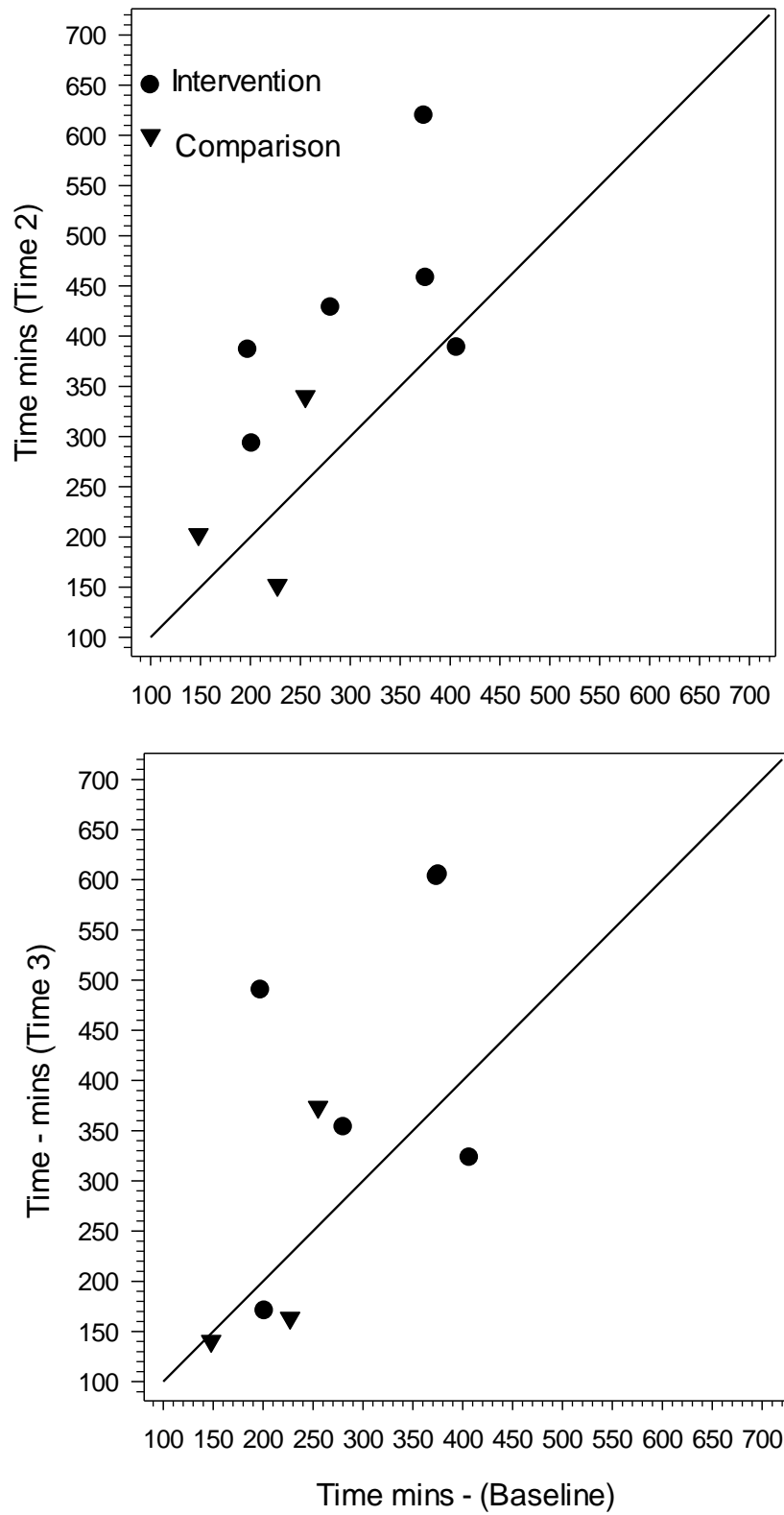


Figure 14. VSG Data for Longest Sleep Period (LSP)

Longest Sleep Period - Follow-up

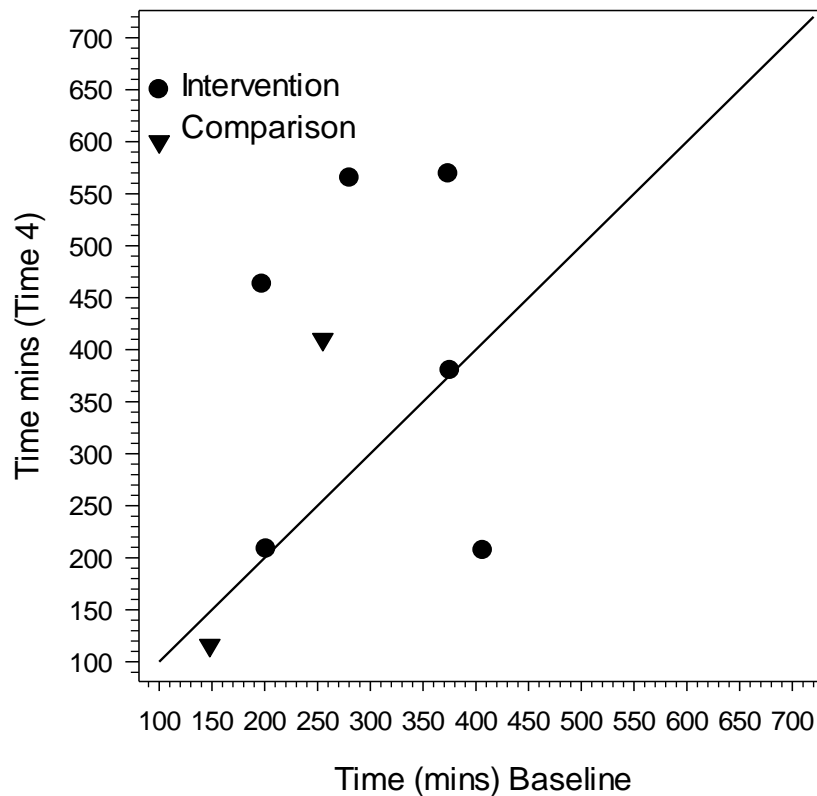


Figure 15. VSG Data for Longest Sleep Period (LSP) at follow up

Longest Self-Regulated Sleep period (LSRSP)

Figure 16 shows the LSRSP of each group between baseline and intervention, and baseline and post intervention. Figure 17 shows the follow up data for LSRSP.

For the intervention group, from baseline to intervention the LSRSP increased for most infants, however Mike decreased slightly, (3 minutes). At post intervention all six intervention participants appeared to have increased in their LSRSP. At follow up this was consistent for all participants except Mike who again decreased, below baseline minutes.

For the comparison group both Scott and Peter increased, however Ben appeared to have decreased slightly (7 minutes). At post intervention both Ben and Scott appeared to

have decreased in their LSRSP, with Peter showing a further improvement. This trend was also continued at the follow up phase.

In summary, Figure 16 shows that LSRSP for all intervention participants had increased at post intervention, meaning that all infants could sleep for longer durations with sustained quiet awake periods. This was consistent at follow up for all participants in the intervention group except Mike. An increased LSRSP, may indicate the infant's ability to self-soothe also increased and their need for parental intervention and attention may have decreased. For the comparison group, again only Peter increases while both Ben and Scott decrease in their LSRSP.

Longest Self-regulated Sleep Period

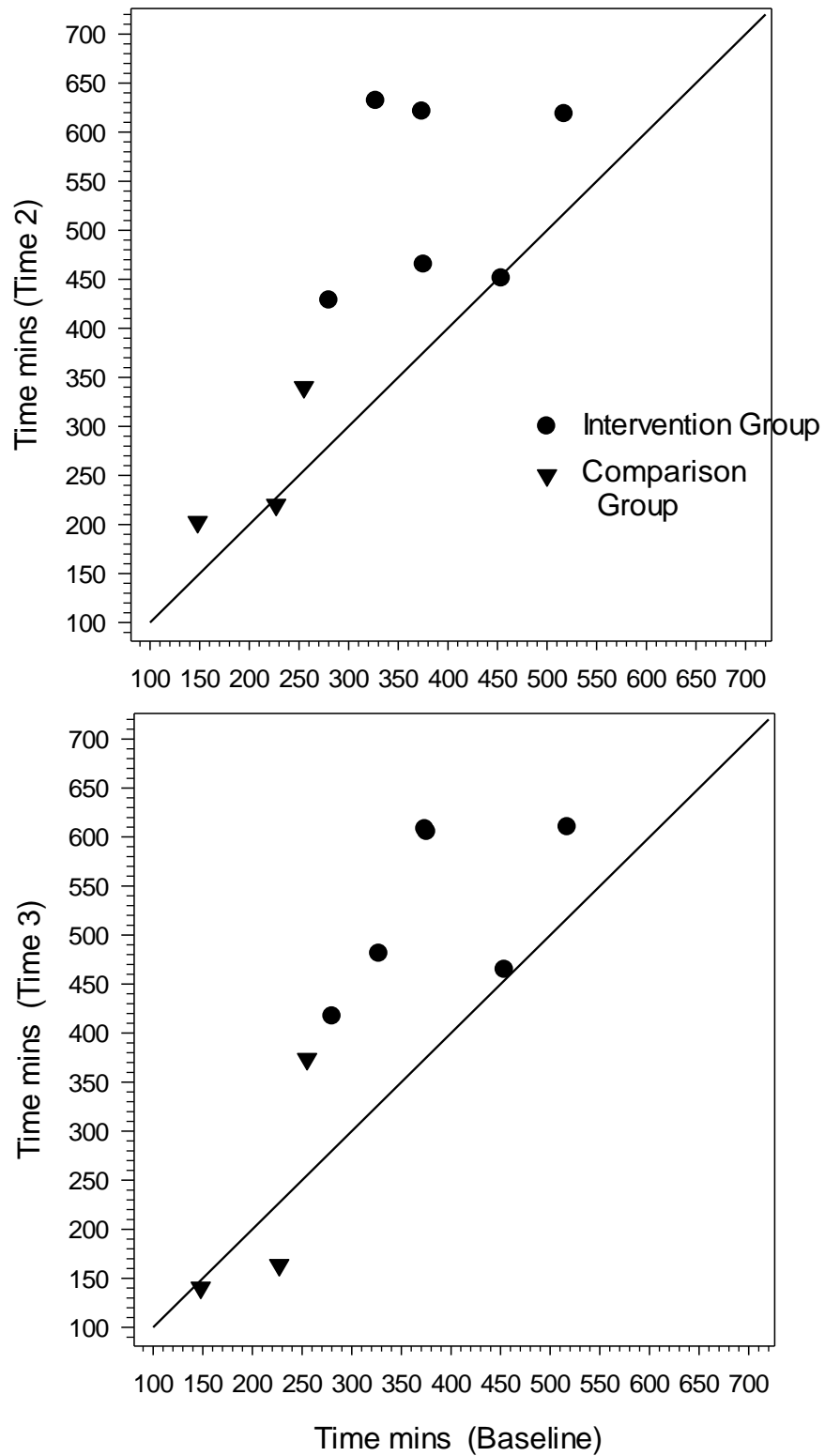


Figure 16. VSG Data for Longest Self-Regulated Sleep Period (LSRSP)

Longest Self-regulated Sleep Period Follow-up

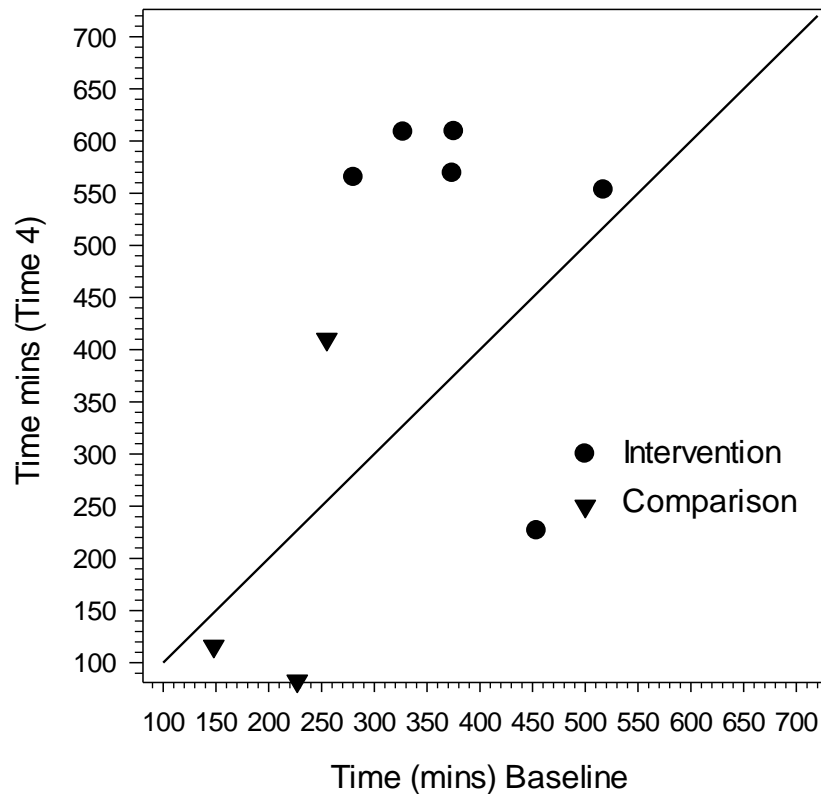


Figure 17. VSG Data for Longest Self-Regulated Sleep Period (LSRSP) at follow up

Sleep-Wake Transitions

Figure 18 shows the sleep wake transitions of infants from baseline to intervention and from baseline to post intervention. Figure 19 shows sleep-wake transitions from baseline to follow up.

From baseline to intervention, Hamish, Mike, Sheryl and Wendy decreased in their sleep-wake transitions and both Rebecca and Yvonne increased slightly in their sleep-wake transitions (1.5 and 2 respectively). From baseline to the post intervention phase the decreases in sleep-wake transitions for Hamish, Sheryl and Wendy were sustained. Mike and Yvonne's number of sleep state transitions stayed the same. Rebecca showed a

reduction in number (after an initial increase at the intervention phase). At follow-up Hamish, Sheryl, Wendy and Yvonne all decreased and both Mike and Rebecca showed an increase in number.

All comparison group infants decreased from baseline to intervention and this remained at post intervention. At follow up Scott increased slightly from his baseline numbers, and both Peter and Ben remained with a decreased number of sleep-wake transitions.

In summary, this decrease in sleep-wake transitions shown at the post intervention phase for Hamish, Sheryl, Wendy and Rebecca implies that infants were shifting between wake and sleep periods less, which suggests that sleep consolidation is occurring. For the comparison group, all infants showed a decrease in their sleep-wake transitions.

Sleep-Wake Transitions

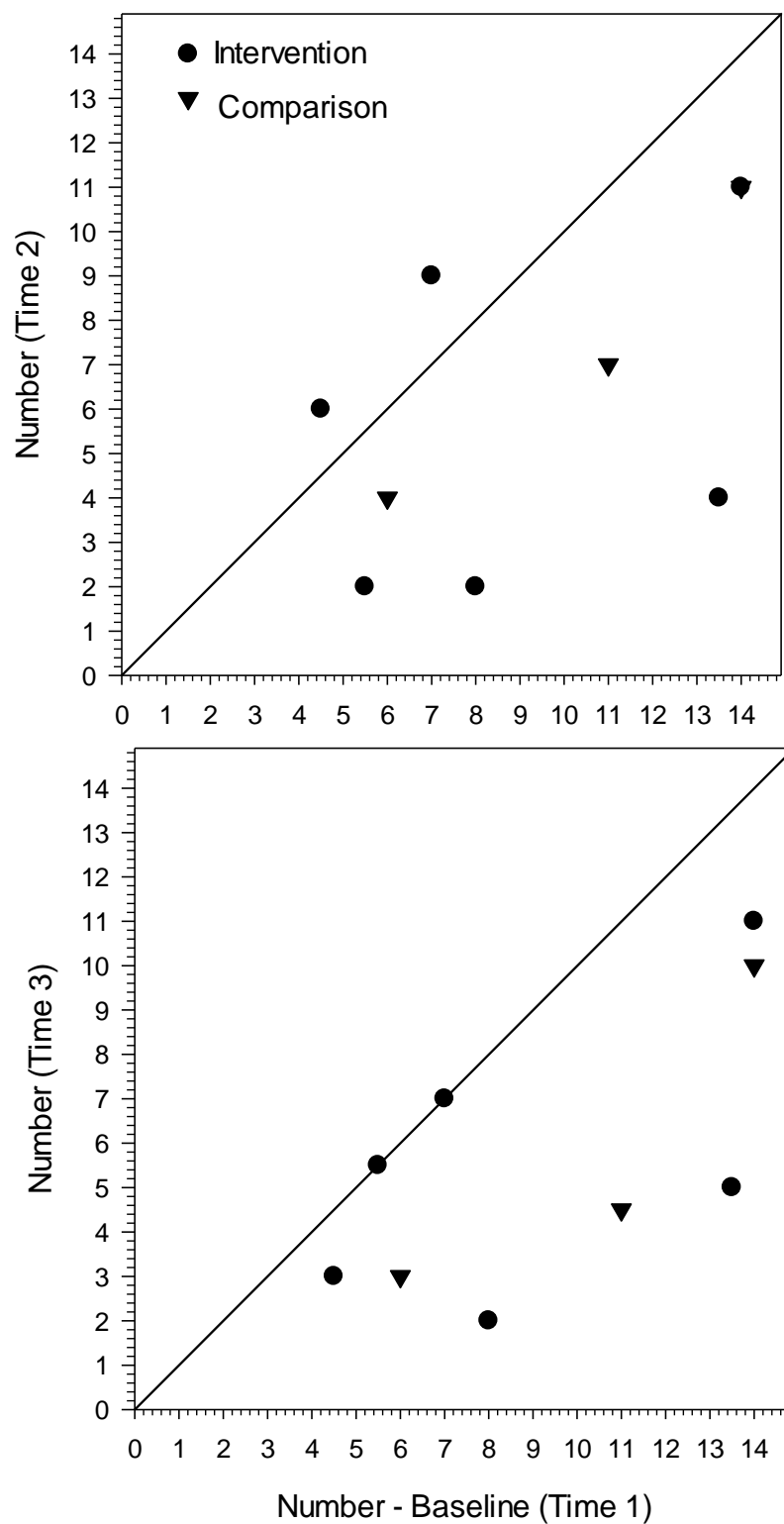


Figure 18. VSG Data for Sleep-Wake transitions

Sleep-Wake Transitions - Follow-up

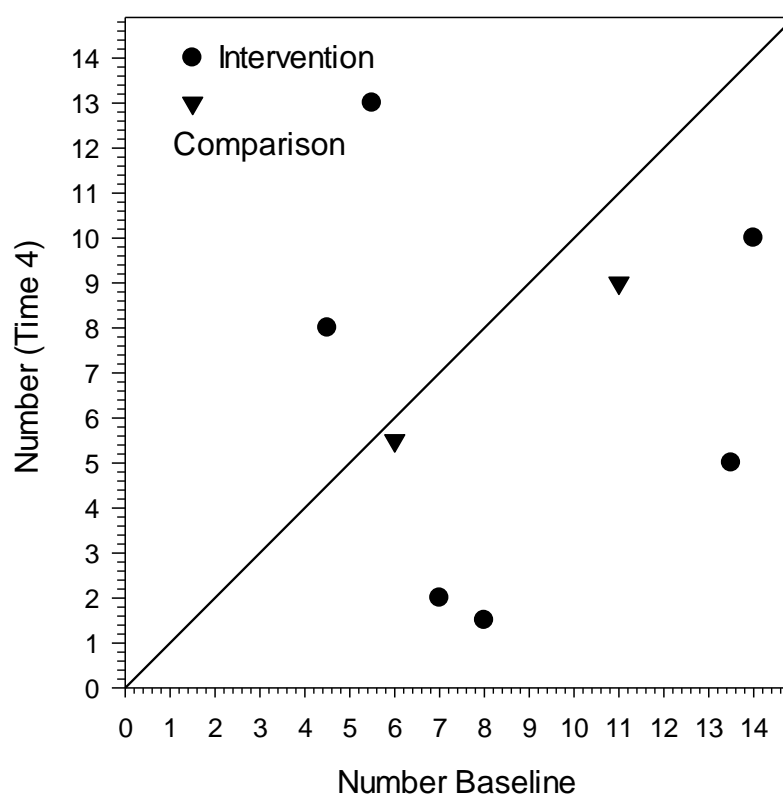


Figure 19. VSG Data for Sleep-Wake transitions at follow up

Sleep-State Transitions

Figure 20 shows the number of sleep state transitions between baseline and intervention as well as baseline and post intervention. Figure 21 shows the number of sleep-state transitions between baseline and follow-up.

From baseline to the intervention phase, in the intervention group, Mike and Sheryl decreased in their transitions and Rebecca, Wendy and Yvonne all increased in their transitions. Hamish appeared to stay relatively the same (0.5 increase). From baseline to post intervention, Hamish, Mike and Sheryl, all decreased, and Rebecca, Wendy and Yvonne all increased in their number of sleep-state transitions. At follow up, Hamish, Mike, and

Wendy decreased, and Rebecca, Sheryl, and Yvonne all increased in their number of sleep-state transitions.

For the comparison group from baseline to intervention Peter and Ben decreased and Scott showed a slight increase (0.5 transitions). This remained steady at post intervention, with Peter and Ben showing a further decrease and Scott showing a slight increase (1.5 transitions). At follow up, all participants had a decrease of sleep-state transitions from baseline numbers.

In summary, for the intervention group, Rebecca, Wendy and Yvonne all showed an increase in their number of sleep-state transitions at the post intervention phase, which implies that after the intervention had been implemented, these three participants could sleep through a greater number of transitions without an awake period. In the comparison group, Scott increases in his sleep-state changes and both Ben and Peter decrease.

Sleep-State Transitions

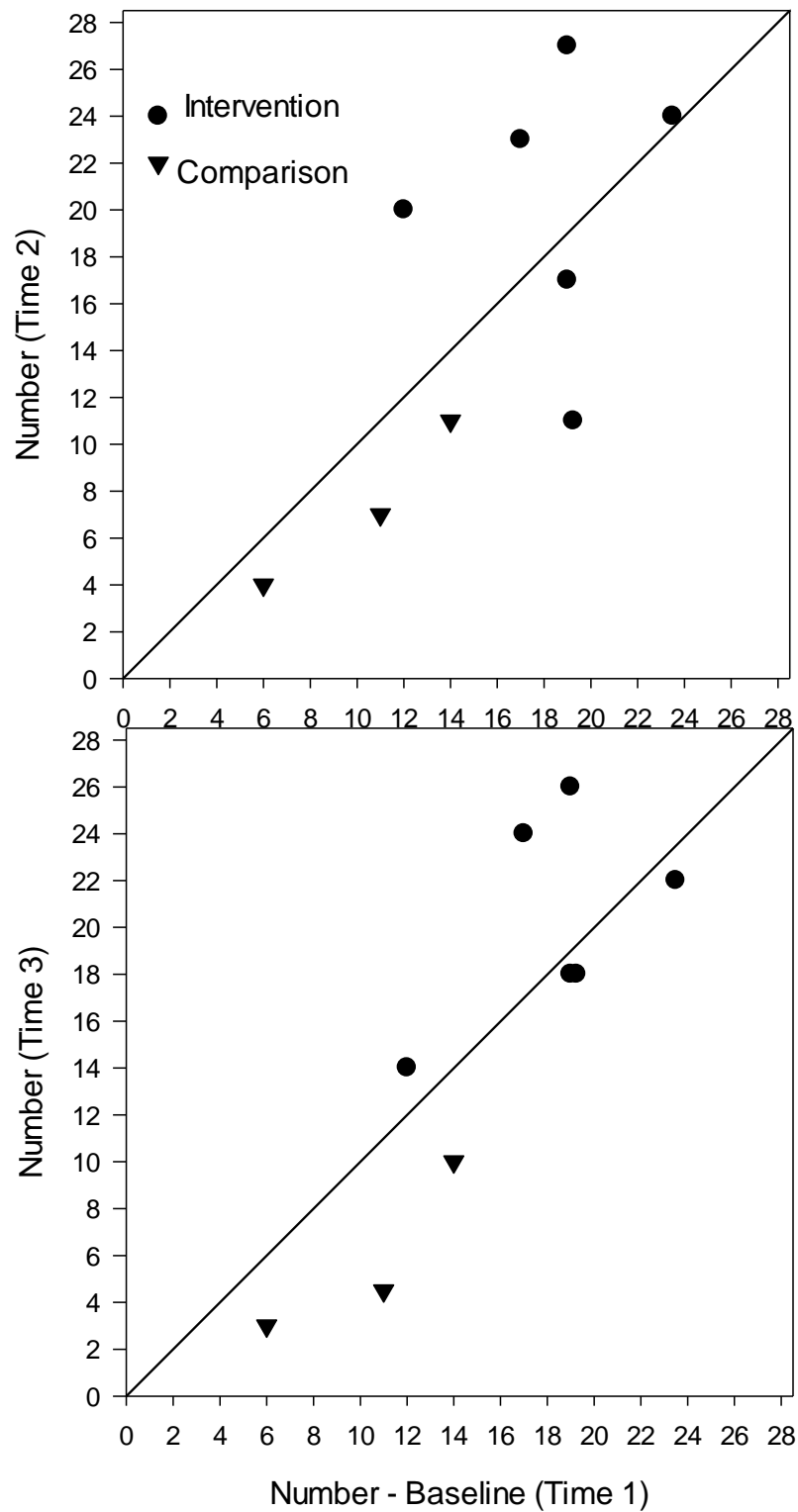


Figure 20. VSG Data for Sleep-State Transitions

Sleep-State Transitions - Follow-up

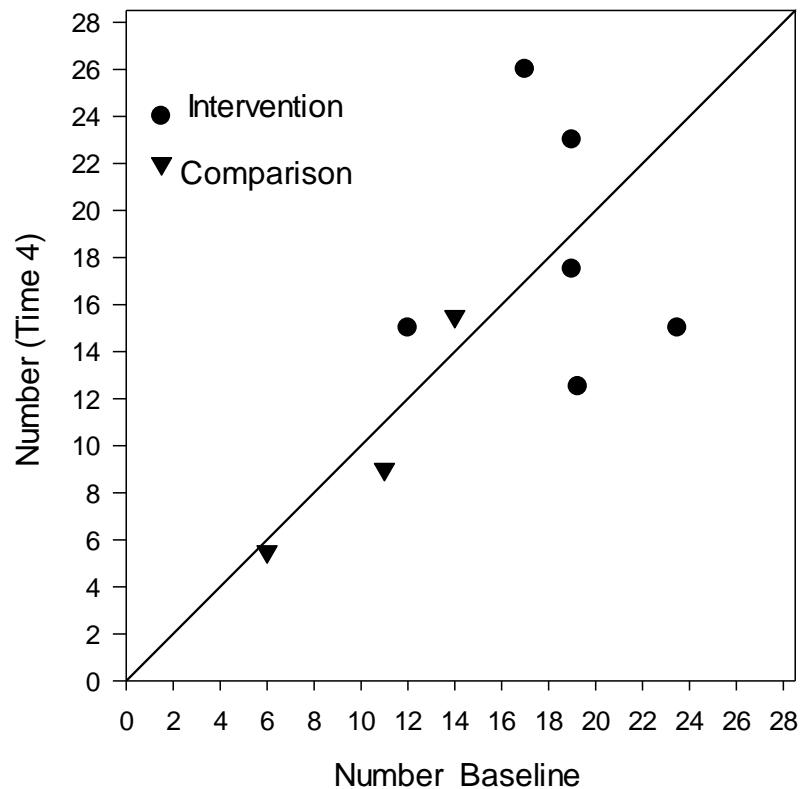


Figure 21. VSG Data for Sleep-State Transitions at follow up

REM Tolerance

Figure 22 shows the REM tolerance for participants from baseline to intervention and from baseline to post intervention. Figure 23 shows REM tolerance at the follow-up phase.

For the intervention group, from baseline to intervention, Mike and Sheryl showed a decrease in their REM tolerance and Hamish, Rebecca, Wendy and Yvonne all showed an increase at the intervention phase. At the post intervention phase Wendy and Yvonne both showed an increase of REM tolerance, Rebecca, Sheryl and Mike all showed a slight change (increase by 1, increase by 0.5 and decrease by 0.5 respectively), and Hamish remained the same. At follow up, Hamish and Mike decreased in REM tolerance, Rebecca and Wendy remained relatively the same, and both Sheryl and Yvonne increased.

For the comparison group Peter and Ben both decreased REM tolerance and Scott remained the same from baseline to intervention. This trend was consistent at the post intervention phase with Peter and Ben showing further decreases and Scott still remaining the same. At follow-up all participants had decreased in REM tolerance.

In summary, for the intervention group, Wendy, Yvonne, Rebecca, Sheryl and Hamish all show an increase in REM tolerance, this suggests that the infant are sleeping through a phase of REM (active) sleep without an awake period. In the comparison group, again Ben and Peter decrease, while Scott shows an increase.

REM Tolerance

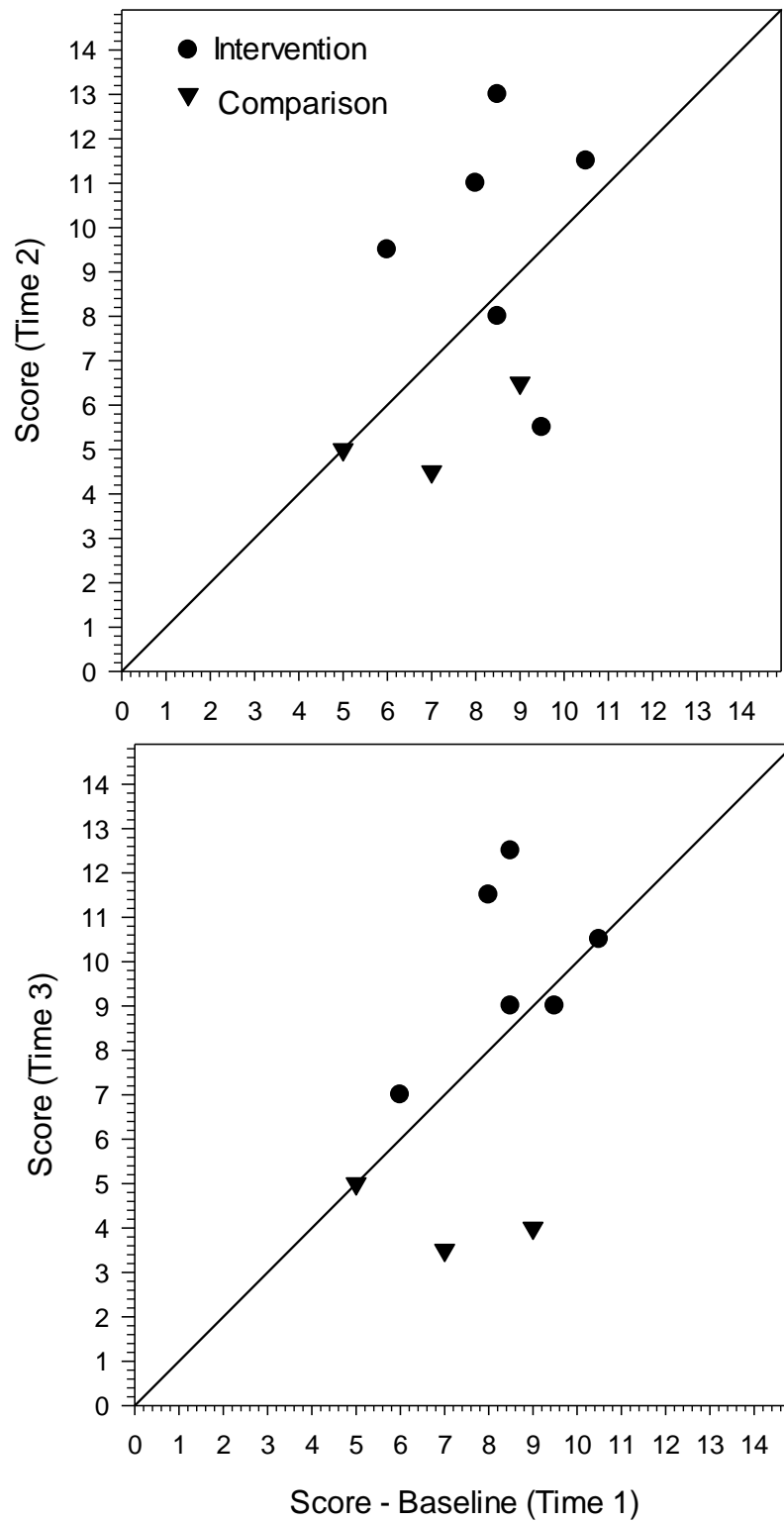


Figure 22. VSG data for REM Tolerance

REM Tolerance - Follow-up

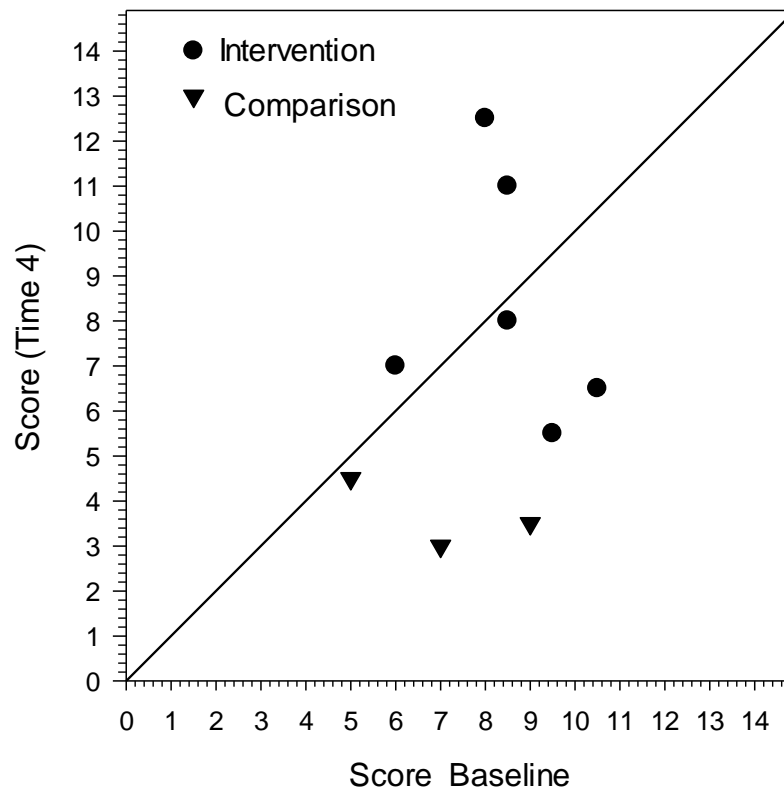


Figure 23. VSG data for REM Tolerance at follow-up

Summary: Changes in sleep-state organisation

In summary, for the intervention group the results show that infants responded differently to the intervention. The expected changes that were to be observed in order to see sleep state changes were as follows: an increase in total sleep time, an increase in the percentage of quiet sleep, an increase in sleep efficiency, an increase in LSP, an increase in LSRSP, a decrease in sleep-wake transitions, a decrease in sleep-state transitions and lastly an increase in REM tolerance. These changes imply that intervention infants did indeed have a change in sleep, however, only some expected changes were shown in the comparison group. Therefore, in the increased number of changes shown by intervention participants may have been in response to the implementation of the intervention and the elimination

of intense parental soothing behaviours. These changes in sleep state organisation for participants in both the intervention and comparison groups are summarised in Table 5.

Changes in Negative Emotionality

Figure 26 shows the changes in negative emotionality of participants from baseline to intervention and from baseline to post intervention. Figure 27 shows negative emotionality at the follow-up phase.

From baseline to intervention for the intervention group participants both Wendy and Hamish decreased in their negative emotionality behaviours, Yvonne and Mike increased and both Rebecca and Sheryl remained the same. From baseline to post intervention Wendy, Hamish, and Rebecca decreased, Yvonne remained the same and Mike and Sheryl increased in their negative emotionality behaviours. At follow up, Mike and Sheryl both showed a decrease, Rebecca and Hamish slightly increased and Wendy and Yvonne remained the same.

For the comparison group from baseline to intervention both Peter and Scott decreased, and Ben remained the same. This trend was consistent at post intervention also. However, at follow up this group all showed an increase in their negative emotionality behaviours.

Negative Emotionality

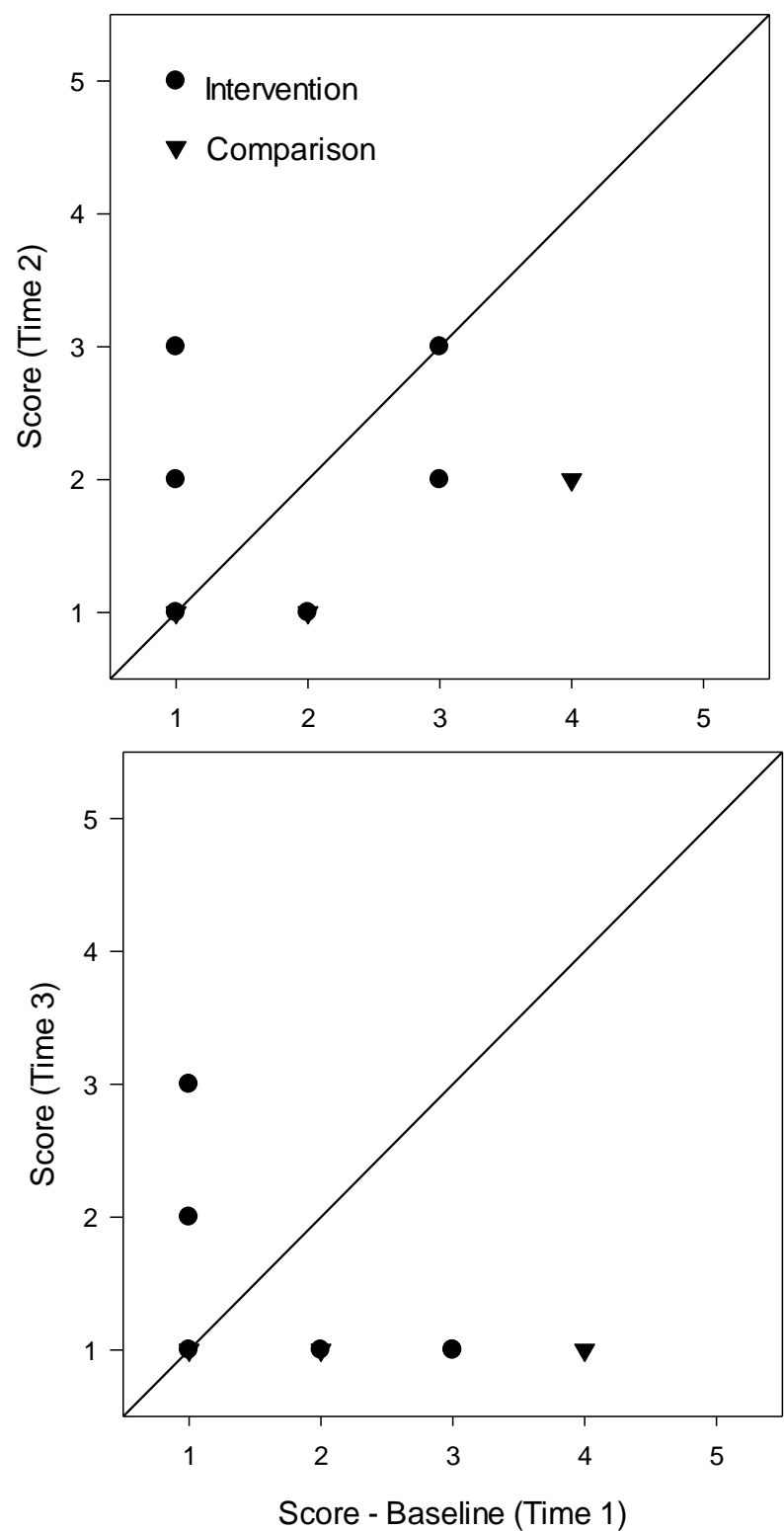


Figure 26. Negative Emotionality Data

Negative Emotionality - Follow-up

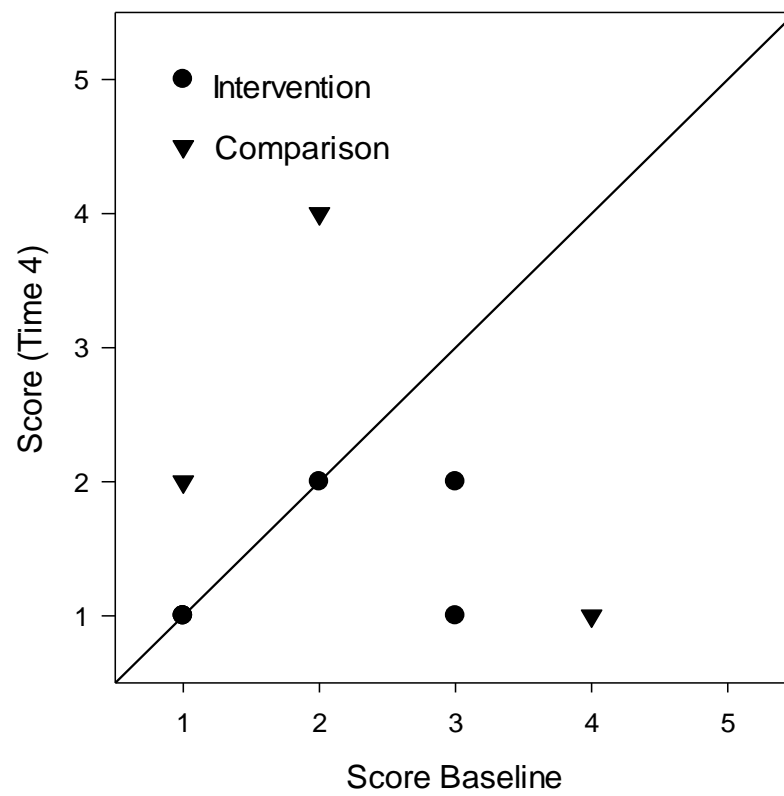


Figure 27. Negative Emotionality Data at follow-up

Discussion

The purpose of this study was to examine how a gradual sleep intervention influences the behavioural and state aspects of sleep in infants with ISD and if there were any changes in negative emotionality that coincided with the sleep changes. There were two different gradual interventions for the parents to choose from, namely extinction with minimal check and extinction with parental presence. Both of these gradual sleep interventions have been found effective for ISD in many studies (France & Blampied, 2005; Wilson, 2013; Kempler, et al., 2016). However, although these results are valuable to the knowledge of ISD, apart from Wilson, (2013), the studies rely on parent report data. A limitation to parent report data is that parents can only record and respond to wakings which are signalled. Therefore, the silent awakenings of the infants are not recorded. VSG proposes another technique to observe infants that also allows silent awakenings to be looked at, as well as infant sleep-state changes. Therefore, this study endeavours to answer the question about infant sleep behaviours and infant sleep state changes in conjunction with the implementation of a gradual sleep intervention. The following three specific questions were posed, firstly, was the gradual sleep intervention effective? Secondly, how did the sleep architecture and sleep behaviours change? And thirdly how did negatively emotionality change throughout the study?

Parental Adherence to the Intervention

Firstly, in order to answer the three questions, parental adherence to the intervention needs to be examined. For both interventions, namely extinction with parental presence and extinction with minimal check, its crucial for parents to adhere to the soothing recommendations. As intense and overstimulating bedtime behaviours have shown to be

unfavourable, these interventions attempt to decrease behaviours. As shown in Table 5 (column 12), intervention parents all showed a decrease in their bedtime soothing techniques, except Yvonne's parents who remained the same, it can be shown that parents did in fact adhere to the interventions that were implemented.

Question One: Was the gradual sleep intervention effective in reducing problematic ISD?

This question can be answered by looking at the sleep diary data for the infants, namely the following three variables, SOD, frequency of signalled night wakings and the duration of signalled night wakings. If the gradual sleep intervention was effective, then we would expect to see a reduction in the SOD, a reduction in the frequency of signalled night wakings for infants and also a reduction in the duration of these signalled night wakings. Only the signalled night wakings are observed here as the parental report data does not consider silent night wakings. Due to the variability of the data, information from the original study (Akdogan, 2018) was also used, which is shown on Table 5. From this Table it is evident that intervention participants showed desirable changes in SOD, night waking duration and night waking frequency when compared to the participants who did not receive the intervention. These infants (comparison group) showed increased variability.

What is interesting at the post-intervention phase for the following intervention participants, Wendy, Hamish and Sheryl is that they all show an initial increase in their signalled durations but a decrease in their signalled night waking frequency, meaning that although they were waking less, the duration of these awake periods were longer. This is the opposite for Rebecca, who was waking more frequently but the duration of her awake period was shorter. Therefore, in summary the gradual sleep intervention was shown to be

effective in reducing SOD, night waking duration and night waking frequency, of infants with ISD.

Question Two: How did the sleep architecture and/or the sleep behaviours change, in response to the gradual intervention for ISD?

This question can be looked at with the VSG data variables, namely total sleep time, percentage of quiet sleep, sleep efficiency, LSP, LSRSP, sleep-wake transitions, sleep-state transitions and REM tolerance. If the gradual sleep intervention did influence the sleep architecture (sleep-state changes) of infants with ISD, it would be seen that the total sleep time, percentage of quiet sleep, sleep efficiency, LSP and REM tolerance would increase, and the sleep-wake transitions, as well as sleep-state transitions would decrease. In terms of sleep behaviours changing in response to the intervention we would see LSRSP increasing as this may imply that infants are increasing their self-soothing behaviours and not requiring parental intervention or attention to reinitiate sleep. These variables will now be discussed individually.

Total Sleep Time

If a gradual sleep intervention impacts sleep state changes we would expect to see an increase in total sleep time for intervention participants, indicating infants were sleeping for longer periods of time. This was evident for four of the six participants in the intervention group, where Yvonne, Rebecca, Mike and Sheryl all increase in their total sleep time, however Wendy and Hamish decrease. In the comparison group all infants decreased in their total sleep time. Therefore, it can be concluded that a behavioural intervention does increase total sleep time, and this may not be due to a developmental change (as

comparison group participants did not show an increase). This suggests sleep consolidation and maturation is occurring.

Percentage of Quiet Sleep

If a gradual sleep intervention impacts sleep state changes we would expect to see an increase in the percentage of quiet sleep. Before 6 months of age, infants active sleep consumes between 47-50% of total sleep time and this decreases to 29-49% after 6 months of age (Anders & Keener, 1985; Parmelee, Schulte, Akiyama, Weener, Schultz & Stern, 1968), while quiet sleep increases from around 19-26% at birth to 40-42% at six months (Anders & Keener, 1985; Parmelee et al., 1968). In the intervention group, all participants increased in the percentage of quiet sleep except for Rebecca and for the comparison group all infants increased except for Scott. Therefore, this may indicate that a gradual sleep intervention helps increase the percentage of quiet sleep, however it may also indicate that this is a developmental aspect of sleep as comparison infants showed the same change.

Sleep Efficiency

If a gradual sleep intervention impacts sleep state changes, we would expect to see an increase in sleep efficiency. Meaning infants would increase in the amount of time they spent in bed asleep as opposed to awake. In the intervention group, all infants except Mike increase in their sleep efficiency, and in the comparison group all infants except Peter increase in sleep efficiency. Therefore, this change may be due to the intervention, but it may also be due to developmental sleep changes in infants, as the two or the three comparison group infants showed similar changes.

LSP

If a gradual sleep intervention impacts sleep state changes, we would expect to see an increase in LSP. The LSP is the longest sleep period for infants, this occurs once every

night. For the intervention group, all participants increased in their LSP except for Mike who showed a decrease. In the comparison group, all infants decreased except Peter who showed an increase. This change in LSP suggests that intervention infants' sleep states were showing maturation following a gradual intervention, and their ability to sleep for a longer period of time without waking was increasing.

Sleep-Wake transitions

If a gradual sleep intervention impacts sleep state changes, we would expect to see a decrease in sleep-wake transitions. Sleep-wake transitions are where infants change from a state of sleep to a state of awake, with the implementation of an intervention it would be expected for infants to sleep through state changes without an awake period. In the intervention group all infants decreased in their sleep-wake changes except for Mike. Showing that infants could sleep through state changes without an awake period. In the comparison group, infants also all decreased. Therefore, this change could be a result of the development of sleep rather than intervention effects due to comparison participants all showing the desired change.

Sleep-State Transitions

If a gradual sleep intervention impacts sleep state changes, we would expect to see a decrease in sleep-state transitions. However, in the intervention group four of the six participants showed an increase in sleep-state transitions, namely, Wendy, Yvonne, Rebecca and Mike. In the comparison group, Scott also showed an increase whereas Ben and Peter showed a decrease. This variability in sleep-state transitions in both groups, makes it hard to draw a conclusion for sleep-state transitions.

REM Tolerance

If a gradual sleep intervention impacts sleep state changes, we would expect to see an increase in REM tolerance. This would indicate that infants can sleep through a period of REM sleep without an awake period. For the intervention group participants all infants except Mike increased in their REM tolerance and for the comparison group participants, all decreased except Scott. Therefore, this may imply that after a behavioural intervention was implemented, infants were able to sleep through increased changes of REM than before the intervention.

LSRSP

If a gradual sleep intervention impacts sleep behaviour changes, we would expect to see an increase in LSRSP. It was found that all intervention group infants had an increase in LSRSP after the intervention and this was still evident at the follow up phase for all except Mike. Therefore, in summary, this shows that after the intervention infants could reinitiate sleep on their own accord after a silent awake period, without the need for parent intervention or attention. What is also interesting to note here is that for the comparison group two out of the three infants decreased in their LSRSP. These findings may suggest that a gradual intervention could help increase an infant's ability to self-soothe.

Therefore, in summary, it is evident that after a gradual intervention was implemented for ISD, Wendy, Sheryl, Hamish, Rebecca and Yvonne all show the expected changes that result from sleep-state development and consolidation, in other terms these results show an improved organisation of sleep following a gradual intervention. Mike however did not. In terms of sleep behaviours all infants (except Mike) showed an increase in their LSRSP and therefore an increase in their self-soothing behaviours, just as previous studies have found (Wilson, 2013).

Question Three: How did the negative emotionality of the infants change in response to the gradual intervention for ISD?

This question can be looked at with the VSG data that was analysed and scored for negative emotionality (NICHD, 1999). Previous research has shown that difficult temperament is related to infant sleep problems (Carey 1974; Sadeh et al., 1994; Kelmanson, 2004; Sorondo & Reeb-Sutherland, 2015). However, the above research is done with the implementation of perceived temperament measures, namely parental reports, which can be subject to biases and parental perceptions. Therefore, this study set out to answer the above question with the implementation of an objective measure of temperament. This objective measure aims to eliminate parental perceptions and biases. It was expected that as infant sleep problems become less evident their negative emotionality would also decrease. Results showed that Mike increased in negative emotionality behaviours at post intervention and this was slightly reduced at follow up. However, it is important to note here that Mike did not show substantial changes in regard to both his sleep architecture and sleep behaviours. Of the other intervention participants, Wendy showed a decrease in her negative emotionality behaviours after the intervention and this remained stable at the follow-up phase. Sheryl initially increased her negative emotionality behaviours after the intervention, however at the follow-up phase she had decreased them. Hamish decreased in his negative emotionality behaviours after intervention and showed a slight increase (of one score) at the follow-up phase. Rebecca showed a decrease in her negative emotionality behaviours after the intervention and this slightly increased (by one score) at the follow-up phase. Yvonne remained consistent in her negative emotionality behaviours. In terms of the comparison infants all had increased their negative emotionality behaviours at the follow-up phase.

Therefore, in summary, it is evident that the negative emotionality scores relate to the sleep architecture and sleep behaviour of infants, following a gradual behavioural intervention, like previous studies have shown (Kelmanson, 2004; Sorondo & Reeb-Sutherland, 2015). Specifically, as infants sleep state and sleep behaviours consolidate and show increased organisation, negative emotionality also decreases.

Limitations of the Current Study

When looking at the limitations of the current study, several factors were identified. Firstly, a limitation was the number VSG nights. In each phase of the study; namely baseline, intervention, post intervention and follow up phases only three nights of VSG data was recorded. Of these three nights the first night was discarded as to eliminate from analysis any novel behaviours the parents and infants might exhibit due to the camera being in the room. The second and third nights were then coded and analysed for each infant by the researcher. To reduce the variability of data a greater number of nights being recorded would be beneficial. It would also provide a more representative analysis of sleep at each phase of the study.

Another limitation to this study could be that the camera angle of the VSG recording was not always inclusive of the entire cot. This limited certain sections of the night for certain infants and made sleep state coding difficult. For future research the angle of cameras would be advantageous to ensure the entire cot is being recorded in an effort to not miss any important sleep state changes.

Thirdly, an additional limitation could have been the inability to code comparison group infants sleep (when they were cosleeping) effectively. It was difficult for the researcher to obtain reliable sleep state changes as some movements could not be

differentiated between the parents themselves or the infants. In some instances, the movement of parents awoke infants and disturbed their sleep pattern. Also due to the limited number of comparison infants the data has increased variability. Although measures were taken to reduce this (data from the original study was also used) having a larger number of infants would be beneficial to reduce variability and provide a more representative analysis of sleep.

Implications of the Current Study

This study aimed to look at how sleep architecture and sleep behaviours change in infants with ISD, after a gradual intervention is implemented. The findings of this research suggest that a gradual intervention for ISD improves infant sleep by decreasing problematic sleep behaviours. Noticeable change in this study included an intervention effect, shown through decreases in SOD, signalled night waking durations and signalled night waking frequency. As well as maturation and development of sleep-state consolidation, which was shown through increases in total sleep time, percentage of quiet sleep, sleep efficiency, LSP and REM tolerance and decreases in sleep-wake transitions, as well as sleep-state transitions. Change was also shown through infants' ability to increase self-soothing behaviours and reinitiate sleep on their own accord, through increases in LSRSP.

Therefore, there was evidence to support that gradual sleep interventions are beneficial for ISD. In specific terms this means that infants could sleep through a larger number of sleep-state and sleep-wake transition after the intervention was implemented. Supporting the notion that consistency and the removal of excessive parental interactions and intervention at night (which was done by utilising the intervention) can positively influence the organisation of sleep. There is also evidence that the implementation of a

gradual sleep intervention can increase infants' abilities to self soothe. This study takes increased LSRSP as evidence of infants' abilities to reinitiate sleep and self-soothe without the need for parental intervention.

Further evidence showed that as the above changes were occurring, negative emotionality as an objective measure of difficult temperament was also changing. Specifically, as infants decreased problematic sleep behaviours, negative emotionality also decreased.

Accordingly, it is then recommended that more comprehensive future research is conducted to see how these sleep-states are impacted for infants with differing ISD scores. Meaning, this study has found that a gradual intervention changes sleep-state organisation and sleep behaviours of infants, suggesting that an improvement in sleep is associated with changes in sleep-state organisation, however how does this impact infants with different ISD scores? Specifically do infants with more severe scores have different sleep state organisation from infants with less severe ISD? Further research is also required in order to examine the relationship between negative emotionality and sleep interventions. Specifically, although these changes were observed, the order of change was not. For example, were changes in infant sleep associated with decreasing negative emotionality or was a decrease in negative emotionality demonstrating changes in infant sleep disturbance?

Conclusion

The current study aimed to look at the changes in infants sleep quality and negative emotionality. The study found improvement in problematic infant sleep behaviours following the implementation of a gradual sleep intervention. The changes in sleep architecture showed that after a gradual sleep intervention was implemented most infants'

sleep became more consolidated and showed improved organisation. The changes in sleep behaviours of infants after a gradual sleep intervention was implemented also showed beneficial change in the way that infants demonstrated increased abilities to self-soothe and reinitiate sleep after an awake period without the need for parental intervention or attention. In regard to the negative emotionality of infants it was seen that infants decreased in these behaviours.

Therefore, this study was consistent with previous studies (Wilson, 2013; Kempler et al., 2016) that also found changes in infant sleep disturbances after a sleep intervention had been implemented. Further research may benefit from looking at infant sleep states changes over a longer period of time with more VSG recording to document this change in more depth. However, with the improvement in infant sleep after a gradual sleep intervention was used, it may be important to consider in what direction an objective measure of temperament was related to sleep behaviours and sleep architecture.

References

- Akdogan, G. (2018). To intervene or not to intervene: Effects of behavioural sleep interventions on infant attachment quality (Doctoral thesis, University of Canterbury, Christchurch, New Zealand).
- Anders, T. F. (1979). Night waking in infants in their first year of life. *Pediatrics*, 84, 63, 760-864.
- Anders, T.F., Halpern, L.F., & Hua, J. (1992). Sleeping through the night: A developmental perspective. *Paediatrics*, 90, 554–560
- Anders, T. F., & Keener, M. (1985). Developmental course of night time sleep-wake patterns in full-term and premature infants during the first year of life. *Sleep: Journal of Sleep Research and Sleep Medicine*, 8(3), 173-192.
- Anders, T. F., Keener, M., Bowe, T. R., & Shoaff, B. A. (1983). A longitudinal study of night-time sleep-wake patterns in infants from birth to one year. In Call, J. D., Galenson, E., & Tyson, R. L. (Eds.), *Frontiers of Infant Psychiatry*. pp. 150-169. Basic Books Inc, New York.
- Arditi-Babchuk, H., Feldman, R. & Eidelman, A.I. (2009). Rapid eye movement (REM) in premature neonates and developmental outcome at 6 months. *Infant Behaviour and Development*, 32, 27-32
- Becker, P. T., Brazy, J.E., & Grunwald, P.C. (1997). Behavioral state organization of very low birth weight infants: Effects of developmental handling during caregiving. *Infant Behaviour Development*, 20, 503–514.
- Becker, P. T. & Thoman, E.B. (1981). Rapid eye movement storms in infants: rate of occurrence at 6 months predicts mental development at 1 year. *Science*, 212, 1415-1416.

- Beckwith, L., & Parmelee, A. H. (1986). EEG patterns of preterm infant's home environment, and later IQ. *Child Development*, 57(3), 777-789.
- Blampied, N. M. (2017). Analysing Therapeutic Change Using Modified Brinley Plots: History. Construction and Interpretation. *Behaviour Therapy*, 48, 115-127
- Blampied, N. M., & France, K. G. (1993). A behavioural model of infant sleep disturbance. *Journal Of Applied Behaviour Analysis*, 26(4), 477-492.
- Burnham, M. M., Goodlin-Jones, B. L., Gaylor, E. E., & Anders, T. F. (2002). Night time sleep–wake patterns and self-soothing from birth to one year of age: A longitudinal intervention study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 43(6), 713–725.
- Carey, W. B. (1974). Night waking and temperament in infancy. *Journal of Paediatrics*, 84, 756–758.
- Chess, S., & Thomas, A. (1966). *Temperament: Theory and practice*. Yonkers, NY: World Book.
- Colten, H & Altevogt, B. M. (2006). *Sleep Disorders and Sleep Deprivation: An Unmet public health problem*. The national academic press, Washington, DC.
- Crowell, DH., Kapuniai, LE., Boychuk, RB., Light, MJ., & Hodgman, JE. (1982). Daytime sleep state organisation in three-month-old infants. *Electroencephalography and Clinical Neurophysiology*, 53(1), 36-47
- Dahl, R. E. (1996). The regulation of sleep and arousal: Development and psychopathology. *Development And Psychopathology*, 8(3), 3-27.
- Dang-Vu, T. T., Desseilles, M., Peigneux, P. J., & Maquet, P. (2006). A role for sleep in brain plasticity. *Paediatric Rehabilitation*, 9(2), 98-118.

- Dittrichova, J. (1966). Development of Sleep in infancy. *Applied Physiology*, 21(4), 1243-1246
- Eugene, A. & Masiak, J. (2015). The Neuroprotective aspects of sleep. *MED tube Science*, 3, 35-40
- Field, T. (2017). Infant sleep problems and interventions: A Review. *Infant behaviour and development*, 47, 40-53
- France, K. G. (1992). Behaviour characteristics and security in sleep disturbed infants treated with extinction. *Journal of Paediatric Psychology*, 17, 467-475
- France, K. G., & Blampied, N. M. (1993). A Behavioral Model of Infant Sleep Disturbance. *Journal of Applied Behaviour Analysis*, 26(4), 477-492
- France, K. G., & Blampied, N. M. (1999). Infant sleep disturbance: Description of a problem behaviour process. *Sleep Medicine Reviews*, 3(4), 265-280.
- France, K. G., & Blampied, N. M. (2005). Modifications of systematic ignoring in the management of infant sleep disturbance: Efficacy and infant distress. *Child And Family Behaviour Therapy*, 27(1), 1-16.
- France, K. G., Blampied, N. M., & Henderson, J. M. T. (2003). Infant Sleep Disturbance. *Current Paediatrics*, 13, 241-246
- Gaylor, E. E., Goodlin-Jones, B. L., & Anders, T. F. (2000). Classification of young children's sleep problems: A pilot study. *Journal Of Child And Adolescent Psychiatry*, 40(1), 61-67.
- Gozal, D. (1998). Sleep-disordered breathing and school performance in children. *Pediatrics*, 102, (3), 616–620.

- Gradisar, M., Jackson, K., Spurrier, N. J., Gibson, J., Whitham, J., Williams, A. S. Dobby, R., & Kennaway, D. J. (2016). Behavioural interventions for infant sleep problems: a randomised controlled trial, *Paediatrics*, 137, 1-10
- Henderson, J. M. T., France, K. G., Owens, J. L., & Blampied, N. M. (2010). Sleeping through the night: The consolidation of Self-regulated sleep across the first year of life. *Paediatrics*, 126(5), 1081-1087
- Hiscock, H., & Wake, M. (2002). Randomised controlled trial of behavioural infant sleep intervention to improve infant sleep and maternal mood. *British Medical Journal*, 324, 1062–1065.
- Kagan, J. (2003). Biology, context, and developmental inquiry. *Annual review of Psychology*, 54, 1-23
- Kagan, J., Reznick, J. S., Clarke, C., Snidman, N., & Garcia-Coll, C. (1984). Behavioural inhibition to the unfamiliar. *Child Development*, 55(6), 2212-2225
- Kelmanson, I. A. (2004). Temperament and sleep characteristics in two-month old infants. *Sleep and Hypnosis*, 6, 67-73
- Kempler., L, Sharpe L, Miller CB, Bartlett D. J. (2016). Do psychosocial sleep interventions improve infant sleep or maternal mood in the postnatal period? A systematic review and meta-analysis of randomized controlled trials. *Sleep Medicine Review*, 29, 15-22
- Kobayashi, K., Oka, M., Inoue, T., Ogino, T., Yoshinaga, H., & Ohtsuka, Y. (2005). Characteristics of slow waves on EEG associated with Epileptic spasms. *Epilepsia*, 46(7), 1098-1105
- Lam, P., Hiscock, H., & Wake, M. (2003). Outcomes of infant sleep problems: a longitudinal study of sleep, behaviour and maternal well-being, *Paediatrics*, 111, 203-207

- Matthey, S. & Crnec, R. (2012). Comparison of two strategies to improve infant sleep problems and associated impacts on maternal experience, mood and infant emotional health: A single case replication design study. *Early Human Development*, 88(6), 437-442
- Morrison, D. N., McGee, R., & Stanton, W. R. (1992). Sleep problems in adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*, 31, 94–99.
- NICHD Early Child Care Research Network. (1999). Child care and mother–child interaction in the first three years of life. *Developmental Psychology*, 35, 1399–1413
- O’Brien, L. M., Holbrook, C. R., Mervis, C. B., Klaus, C. J., Bruner, J. L., Raffield, T. J. (2003). Sleep and neurobehavioral characteristics of 5- to 7-year-old children with parentally reported symptoms of attention-deficit/ hyperactivity disorder. *Paediatrics*, 111, 554–563.
- Owens, J.L., France, K.G., & W, L. (1999). Behavioural and cognitive-behavioural interventions for sleep disorders in infants and children: A Review. *Sleep Medicine Reviews*, 3, 281-302
- Parmelee, A. H., Schulte, F. J., Akiyama, Y., Weener, W. H., Schultz, M. A., & Stern, E. (1968). Maturation of EEG activity during sleep in premature infants. *Electroencephalography and Clinical Neurophysiology*, 24(4), 319-329.
- Paulussen-Hoogeboom, M. C., Stams, G. J., Hermanns, J. M., & Peetsma, T. T. (2007). Child negative emotionality and parenting from infancy to preschool: A meta-analytic review. *Developmental Psychology*, 43(2), 438-453
- Putnam, S. P., Sanson, A. V., & Rothbart, M. K. (2002). Child temperament and parenting. In M. H. Bornstein (Ed.), *Handbook of parenting* (Vol. 1, pp. 255–277). London: Erlbaum.
- Sadeh, A. (1994). Assessment of intervention for infant night waking: Parental reports and activity-based home monitoring. *Journal of Consult Clinical Psychology*, 62, 63–68.

- Sadeh, A. (2005). Cognitive-behavioral treatment for childhood sleep disorders. *Clinical Psychology Review*, 25, 612-628.
- Sadeh, A., & Anders, T. F. (1993). Infant sleep problems: Origins, assessment, interventions. *Infant Mental Health Journal*, 14(1), 17-34.
- Sadeh, A., Gruber, R., & Raviv, A. (2002). Sleep, neurobehavioral functioning and behavior problems in school-age children. *Child Development*, 73, 405–417.
- Sadeh, A., Lavie, P., & Scher, A. (1994). Maternal perceptions of temperament of sleep-disturbed toddlers. *Early Education and Development*, 5, 311–322.
- Sadeh, A., Raviv, A., & Gruber, R. (2000). Sleep patterns and Sleep disruptions in School-age Children. *Developmental Psychology*, 36(3), 291-301
- Sadeh, A., Tikotzky, L. & Scher, A. (2010). Parenting and infant sleep. *Sleep Medicine Reviews*, 2, 89-96
- Salzarulo, P., & Ficca, G. (Ed.). (2002). *Awakening and sleep-wake cycle across development*. Amsterdam/Philadelphia: John Benjamin's Publishing Company.
- Sanson, A., Hemphill, S. A., & Smart, D. (2004). Connections between temperament and social development: A review. *Social Development*, 13, 142–170.
- Scher, A. (2005). Infant sleep at 10 months of age as a window to cognitive development. *Early Human Development*, 81, 289-292.
- Sheldon, S. H. (2006). Sleep in infants and children. In Lee-Ching, T. *Sleep: A comprehensive handbook* (pp. 507-510). Retrieved from <http://www.onlinelibrary.wiley.com>.
- Sitnick, S. L., Goodlin-Jones, B. L., & Anders, T. F. (2008). The use of actigraphy to study sleep

disorders in pre-schoolers: Some concerns about detection of night-time awakenings. *Sleep*, 31(3), 395-401.

Sorondo, B. M., & Reeb-Sutherland, B. C. (2015). Associations between infant temperament, maternal stress and infants sleep across the first year of life. *Infant behaviour and development*, 39, 131-135

Tikotzky, L. (2017). Parenting and sleep in early childhood. *Current Opinion in psychology*, 15, 118-124

Wilson, S. (2013). Effects on sleep-state organisation of a behavioural intervention for infant sleep disturbance (Master's Thesis, University of Canterbury, New Zealand). Retrieved from <https://ir.canterbury.ac.nz/handle/10092/8044>

Zeifman, D. M. & James-Roberts, I. S (2017). Parenting the crying infant. *Current opinion in psychology*, 15, 149-154.

Zentner, M., & Shiner, R. L. (Eds.). (2012). *Handbook of temperament*. Retrieved from <https://ebookcentral.proquest.com>